THE UNIVERSITY OF ALBERTA

# EDMONTON'S IMPACT ON SURROUNDING URBAN CENTERS

by

© HY ELIASOPH

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled EDMONTON'S IMPACT ON SURROUNDING URBAN CENTERS, submitted by Hy Eliasoph in partial fulfilment of the requirements for the degree of Master of Arts.

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Supervisor

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.....

Date ..April 15..., 1978

TO MY PARENTS:

who provided me with the
opportunity for achievement

## Abstract

Empirical evidence suggests that the major determinants of growth and development in areas proximate to growing metropolitan centers relate primarily to geographic location. This thesis investigates the degree to which locational determinants explain or account for variation among development levels of urban centers proximate to Edmonton. Relevant hypotheses are formulated and tested in order to discern patterns of urban spatial interaction underlying the form of development levels.

The data, obtained primarily from the Census of Canada, are comprised of various development measures or indicators. An *index of development*, constructed via principal components analysis, is used to measure development levels of urban centers in the study area. Two series of linear regression analyses are conducted. The first set of analyses is intended to test hypothesized relationships between variations among development levels of urban centers, and (1) distance from Edmonton, and; (2) population size. The second set of analyses focuses on the hypothesized effects of commuting on the form of development levels around Edmonton.

Considering all urban centers in the study area, the findings indicate that development levels are inversely related to distance from Edmonton and directly related to population size. However, the effect of commuting on these relationships is considerable. Whereas the overall strength and

significance of these relationships derives from urban centers located in the Edmonton commuting hinterland, variation among development levels of urban centers beyond the commuting hinterland cannot be explained by their distance from Edmonton or their population size. The analyses also show that the form of development levels around Edmonton features (1) an area of *upward transition*, characterized by high levels of development, within a radius of approximately 35 kilometers, and; (2) a surrounding *downward transitional* area with low levels of development, extending between 35 to 150 kilometers from Edmonton. Though the area of *upward transition* is less extensive than the commuting hinterland of Edmonton, recent trends indicate that the former is extending further outward into the commuting hinterland. This evidence strongly suggests that Edmonton is exerting an impact on development levels of urban centers via the labour market and that the magnitude of this impact appears to be consolidating.

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# CHAPTER ONE

# PROCESSES OF URBAN ECONOMIC GROWTH

## I. Introduction

Recent interest in national development[1] emphasizes the importance of a more equitable distribution of both social and economic opportunities and resources (E.F.T.A., 1968 and 1973; U.S. National Goals Staff, 1970; Hagerstrand, 1972; Hansen, 1972; Bourne, 1975). This stems from a recognition that prolonged disparities in the growth of population, incomes, employment opportunities, housing, and access to public and private services are both socially and economically undesirable. The major reason for this uneven growth is the inability of market forces of supply and demand to allocate scarce resources on an equitable bases (Alonso, 1968a and 1968b; Hagerstrand, 1972; E.F.T.A., 1973; Richardson, 1973b; Bourne, 1975). These inequalities are characterized by two extremes: on the one hand, traditional rural areas have experienced relative or absolute declines of growth; on the other hand, metropolitan centers throughout the urban hierarchy have been able to capture a disproportionately large share of national growth. This concentration of growth in metropolitan centers is largely attributable to their ability to perform better a number of important functions such as industrial agglomeration economics and the generation and adoption of innovations upon which growth is contingent.

Relating development to patterns of urbanization has been the focus of recent research in national development (Berry, 1968a, 1970a, 1970b, 1973a, and 1973b; Rodwin, 1970 and 1972; Richardson, 1972, 1973a and 1973b; Cameron and Wingo, 1973; Bourne, 1975). The findings of these studies suggest that metropolitan growth be assessed in relation to those processes that shape regional and national patterns of growth and development. Attempts to correct regional inequalities and achieve a more balanced state of growth must therefore be examined in the context of the national urban system and component metropolitan centers or nodes through which market forces operate (Bourne, 1975). This view of the urban-economic growth process has been placed in perspective by Richardson (1972), wherein he equates processes of urban population growth and economic development. He maintains that the national system of cities is the most efficient form of organization through which market forces operate to achieve economic growth and development.

With regard to processes of urban-economic growth, Berry (1964, 1970b, 1973a) has noted that economic growth is increasingly organized around and through the national system of cities of the urban hierarchy, that is, economic growth processes operate within a particular framework of spatial organization, or *matrix* of urban regions (Berry, 1973a). Two major elements comprise this system of organization (Berry, 1967, 1970b, and 1973a):

(a) a system of cities, hierarchically arranged according to function, and;

(b) corresponding areas of urban influence or urban fields (Friedmann and Miller, 1965) surrounding each of the cities in the system.

Economic growth in this system operates simultaneously along three planes:

(a) outward from the heartland or national metropolitan centers to regional metropolises;

(b) from centers of higher to centers of lower level in the hierarchy, and;

(c) outward from metropolitan centers into their surrounding urban fields.

The typology constructed by Berry is useful in that it provides a framework for examining the organization and operation of economic growth in a spatial context.[2] Of particular relevance is the manner in which growth is made manifest in areas proximate to large and growing urban centers. These *growth centers* can be broadly defined as urban areas capable either of potential or spontaneous growth (Alonso and Medrich, 1972, p. 230) of population, economic activity, employment opportunities, and income levels. An important feature of a growth center is that the benefits of its growth are likely to be felt also in the surrounding areas (E.F.T.A., 1968). Indeed, a central tenet of the growth center concept is that growth in an urban area, whether induced or spontaneous, will benefit a hinterland, raising development levels of a surrounding region via commuting to expanded job opportunities in the growth center or by stimulating economic activity within the hinterland itself (Berry, 1968a, 1970b, 1973a, 1973b, and 1977; Hansen, 1971, 1973a, 1975a, and 1975b; Moseley, 1973b, and 1974; Hodge, 1974; Lamb, 1975). Nichols (1969) incorporates this

feature of a growth center in her definition of a growth pole as:

> an urban center of economic activity which can achieve self-sustaining growth to the point that growth is diffused outward into the pole region and eventually beyond into the less developed region of the nation. (Nichols, 1969, p. 193).

Allen and Hermansen (1968) contend that the transmission of growth from growth centers to the region performs a key role in offsetting regional imbalances which would otherwise arise during the process of economic growth. In this regard, Berry argues that:

> continued urban-industrial expansion in major metropolitan areas should lead to catalytic impacts on surrounding areas. Growth impulses and economic advancement should filter down and spread to smaller places and ultimately infuse dynamicism into even the most tradition-bound peripheries. (Berry and Niels, 1969, p. 288).

The broadest objectives of the present study aim at dermining the form of development levels in the area surrounding the growth center of Edmonton, and investigating the major locational determinants that give rise to, or account for, variations in these levels of development. Since the study will be primarily concerned with measuring and explaining locational factors underlying the form of development levels, a review of the theoretical and empirical issues relating to the organization and operation of urban-economic growth will be presented in the following section.

## II. Theoretical Background

### A. Introduction

Urban-economic growth theorists presently argue that processes

underlying the preconditions and existing conditions of urban-economic growth and development, particularly in areas proximate to large metropolitan centers, can no longer be satisfactorily explained by traditional tools of regional analysis.[3] Higgins, in a recent survey of regional planning policies notes that "the branch of economic theory underlying regional planning (location theory) is in a particularly unsatisfactory state, providing only limited guidance for policy formulation" (Higgins, 1968, p. 477). Similarly, Lampard finds that:

> the general theory of location and space economy is found wanting. . . The theory is intended to determine locations in a framework of general equilibrium. But quite apart from the problem of handling so many complex interrelations, the outcome is still a static system that is geared to the analysis of locational transformation. (Lampard, 1968, pp. 95-96).

Thus, Hansen (1975a), in a review of the limitations of urban growth models, maintains that neither classical location theory nor neo-classical growth theory provide a basis for predicting urban growth nor for explaining those factors underlying this growth. Hansen concludes that:

> In general, the principal reason for which not only location theory and economic base analysis but also such traditional tools of regional analysis as input-output models, central place theory, urban hierarchy studies, industrial complex analysis, and gravity models have so often proven inadequate for policy purposes is that they have failed to take into account the changing nature of the actual determinants of location. (Hansen, 1971, p. 13).[4]

In contrast, the growth center approach provides a more dynamic framework[5] within which to investigate processes of urban-economic growth and implement policies intended to achieve goals of national and regional

economic growth. The evolution of the growth center concept has been, in large measure, a reaction to more traditional tools of regional analysis that have failed to provide adequate means for dealing with increasingly complex and dynamic changes inherent in the process of urban-economic growth. The following sections consider how the growth center concept developed and discuss problems associated with the growth center approach. Emphasis is placed on growth center impact and subsequent effects on surrounding areas.

## B. Unbalanced Growth

The theoretical constructs upon which the notion of growth center impact is based, derive largely from the work of Myrdal (1957) and Hirschman (1958). In formulating a theory of the incidence and transmission of economic growth, Hirschman (1958), following from Perroux (1950 and 1955), recognized that growth is unevenly distributed, occurring with varying degrees of intensity only at specific points on the geographic landscape. Further, once growth is initiated, powerful forces produce a seemingly inherent inertia at initial points of growth. The process underlying this phenomenon, is described by Hirschman as one in which "a national or regional economy, to lift itself to higher levels of income, must and will first develop one or several centers of economic growth" (Hirschman, 1958, p. 183). Moreover, his thesis of *unbalanced growth* maintains that

> the need for the emergence of growing points in the course of the regional development process means that international and interregional inequality of growth is an inevitable concomitant of growth itself. (Hirschman, 1958, pp. 183-184).

Hirschman concludes that initial imbalances of growth will, nonetheless, decrease rather than increase, because both external economies of growing points together with complimentary relations between these points and their hinterland will inevitably result in more balanced regional development.

C. Circular and Cumulative Causation

In a separately developed study of the geographical incidence and spread of growth, Myrdal's findings closely coincide with Hirschman's thesis of *unbalanced growth* (Myrdal, 1958). However, Myrdal arrives at a contrary conclusion with regard to the spatial impact of growing points on development of a surrounding area. Whereas his theory of *circular and cumulative causation* contends that the flow of goods, capital and labour is precisely the vehicle through which the cumulative process evolves, he maintains that this process accentuates rather than lessens regional inequalities of growth.

D. The Growth Space

Based on the work of Myrdal (1957) and Hirschman (1958), Robinson and Salih (1971) contend that the spatial impact of a growth center is, in essence, the result of two sets of opposing forces.

> On the one hand, growth tends to concentrate in some centers and erodes the economic base of surrounding areas; on the other hand, development spreads over surrounding areas, as a result of growth in the center. (Robinson and Salih, 1971, p. 303).

The interplay of the *backwash effects* and *spread effects* of these forces

(Myrdal, 1957, pp. 27-32)[6] takes place over the area in which the center and its surroundings interact - the *growth space*. Thus the relative strength of these two opposing forces of backwash and spread determines the level of development at any one point in the growth space. Furthermore, Robinson and Salih hypothesize a uni-polar growth space with a universe of points arranged about the center. The growth space itself is continuous; therein, each settlement is a sample point. The model assumes that within the growth space the "spread effects" are more pronounced than the "backwash effects", and that "the level of economic development at these points declines with distance from the center, as the degree to which spread effects are felt in the surrounding growth space diminishes . . . " (Robinson and Salih, 1971, p. 304).

Although the model developed by Robinson and Salih to explore assumptions related to the spread of economic development is based on a hypothetical data set, it is valuable insofar as it provides some useful constructs for empirical examination. Of particular relevance is the hypothesized growth space and the assumption of declining levels of economic development at points of increasing distance from the center. Both constructs are utilized in the testing of hypotheses relating to variation in levels of development.

E. Center-Periphery Model

Typical results of the interplay between the forces of "backwash" and "spread" are portrayed by Friedmann in his *center-periphery* model

(Friedmann, 1966 and 1969). In essence, the model is a regional typology describing a sequence of regions evolving in response to forces of "backwash" and "spread". Five regions, independent of scale, are depicted in the center-periphery model:

(a) *Core* regions or "metropolitan economies with a high potential for economic growth" (Friedmann, 1966, p. xv) are arranged hierarchically. These cores provide the impetus and focal point for the growth of the region in which they are located, and are analogous to the growth center.

(b) *Upward transitional zones* are those in which "natural endowments and location relative to core regions suggest the possibility of greatly intensified use of resources" (Friedmann, 1966, p. xvi). The dominant processes at work in these areas are synonymous with the forces whereby spread is effected, giving rise to increasing investment, net migration and rising incomes. As well, these areas are characterized by a high degree of labour market participation in expanding employment opportunities at the core or center.

(c) *Downward transitional zones* are "areas of old established settlement where the essential rural economy is stagnant or in decline and whose particular combination of resources suggests a less intensive development than in the past" (Friedmann, 1966, p. xv). Their distinctive features of net and selective outmigration, aging industrial structure, low productivity and low standard of living are similar to those found in areas where the effects of backwash prevail.

(d) Resource frontiers, and, (e) Special problem regions, are self-explanatory, catch-all regions, used to describe areas that do not conform to Friedmann's conceptual framework.

The first three regions comprise the essential features of Friedmann's center-periphery model; they provide the basic spatial framework for the formulation and testing of hypotheses relating to the form and pattern of development in the urban field. Synthesizing the preceding discussion of the center-periphery model with the earlier consideration of the interplay between forces of backwash and spread that takes place throughout the growth space, there emerges the general thesis that arranged around a growth center or urban core is a broadly concentric series of impacts: an upward transitional zone adjacent to the center where the effects of the spread of growth predominate, gradually giving way to a zone of downward transition in which the effects of backwash prevail. However, before relevant hypotheses can be formulated and tested it will be necessary to investigate various growth center impacts on levels of development in the growth space.

## III. Growth Center Impacts

Implicit in the treatment of forces of backwash and spread is the assumption that levels of development in the growth space surrounding the urban core or growth center are characteristic of traditional rural areas - low incomes, high unemployment, stagnant economy, declining population. Although impacts on the growth space may raise levels of development through spread effects on the one hand, or accelerate trends of developmental

decline on the other hand, considerations of impact are concerned primarily with favourable effects associated with spread. For, it is through the spread effects of growth that declining trends of population and development can be arrested and reversed. For purposes of this study, *spread* may be defined spatially as "the complex set of forces whereby the absolute level of development of a peripheral area is increased because of diffusion from a core" (Gaile, 1973a, p. 3). Possible processes whereby spread is effected are considered in the next section.

## A. Spread Effects of Growth

### i Purchases and Trade

The purchases of food products and resources are often cited as a force whereby spread is effected (Nichols, 1969; Hansen, 1971, 1975a, 1976; Moseley, 1973b). The strength of this force as a viable spread effect, however, has been questioned by Friedmann (1966 and 1969). He maintains that the magnitude of spread effects generated by purchases in resource regions - "zones of new settlement in otherwise virgin territory" (Friedmann, 1966, p. xvii), is often shortlived and generally weaker than expected because of flows or *leakages* of capital back to the core or growth center. As well, the purchase of food products is not seen as a vibrant force primarily because of the inelasticity of demand for such commodities, relative to that of higher-order goods found at the center (Nichols, 1969). With regard to retail purchases, Berry (1960) has suggested that areas proximate to a large metropolitan center may well experience a decline of trade as a result of functional usurption of some

retail activities by the metropolis. Indeed, Berry was able to demonstrate a trend toward the centralization of trade activities in metropolitan centers from surrounding areas. The erosion of the economic base of these areas by the metropolis can be viewed as a backwash effect of metropolitan growth.

ii Diseconomies of Scale

Some of the larger cities of the urban hierarchy have experienced increasing costs of land, labour and resources, resulting from congestion and competition, that have led many industrial activities to seek peripheral locations that offer cheaper production possibilities. These *diseconomies of scale* are often cited as a force whereby spread is effected (Hirschmann, 1958; Hansen, 1975a). Alonso (1968b and 1971) and Richardson (1972), however, present arguments to refute the contention that the larger cities are experiencing diminishing marginal returns associated with diseconomies of scale. They point to the attraction of large urban centers as a major source of industrial employment, technological development and innovation. Although both Alonso and Richardson acknowledge the trend toward increasing industrial decentralization, they argue that this phenomenon is largely the result of other factors that are social and political in nature.

iii Industrial Filtering

Another way in which industrial activities are hypothesized to spread from original centers of growth is through what Thompson terms the *industrial filtering mechanism*, whereby industries *filter down* through the urban hierarchy (Thompson, 1965, 1968, and 1972). According to Thompson

> Invention, or at least innovation, takes place more than proportionately in the larger centers of the more industrial mature regions, and as industries age and their technology improves, skill requirements fall and the industry becomes free - and competitively forced - to relocate in lower wage (lesser skill) areas. (Thompson, 1972, p. 110).

The magnitude of benefits coincident with this phenomenon are largely contingent upon the hierarchical level at or to which filtering takes place. Generally, lower hierarchical urban centers maintaining corresponding skill and wage levels tend to acquire older industries with slower rates of growth. Hierarchical levels beyond which growth rates of industrial filtering decline below the national average are usually found in urban centers with less than 25,000. Hence, the potential benefits associated with the process of industrial filtering are essentially limited to larger urban centers; the lower levels of the hierarchy - those centers that are often in need of growth stimuli, are unable to reap the benefits of such growth.

iv Innovation Diffusion

The theory of *innovation diffusion*, as a process whereby spread is effected, has been the focus of recent growth center impact studies. Indeed, Berry has argued that

> the role played by growth centers in regional development is a particular case of the general process of innovation diffusion, and therefore the sadly deficient "theory" of growth centers can be enriched by turning to the better developed general case. (Berry, 1972, p. 108).

Of particular relevance is the transmission of growth within the hinterland - growth space - of an urban center. For, if it can be shown that there is a

relationship between proximity to a growth center as a source of innovation and the location of adopting centers, then the diffusion of innovation, as a force effecting spread, will have been proven.

Available empirical evidence, however, does not lend weight to the hypothesized role of distance in the innovation diffusion process. The findings of Berry's work relating to the adoption of television sets in the United States (Berry, 1970b, and 1972) led him to question the importance of proximity to urban centers as a factor determining household adoption. Similarly, Tornqvist's study of the spread of television sets in Sweden indicated that distance, as a determining factor in the adoption of this innovation was inconsequential (Tornqvist, 1970).

v Migration

Migration is another process that is claimed to give rise to impact. The overall impact of the migratory process in which rural residents relocate in or near urban centers of growth is, however, far from clear. Moseley (1974) cites two possible extreme impacts on surrounding levels of development: a favourable or spread effect in which unemployment or under-employment is reduced through out-migration, thereby raising per capita, but not necessarily gross, income; and an unfavourable or backwash effect whereby the selective out-migration of the young, talented and skillful reduces income and potential development. Available evidence (Parr, 1966; Thompson, 1972) suggests that although migration may benefit a growth center by raising productivity levels, its effects on areas of out-migration are largely unfavourable. The selective nature of migration robs an area of its youthful, ambitious

and skilled population and labour, and so reduces the ability of an area to attract and sustain growth. Moreover, the loss of migrants decreases the demand for local services and detracts from the tax base, further decreasing the attractiveness of an area.

vi Commuting

Commuting is, to some extent, an alternative to migration in that it enables peripheral residents to partake in employment opportunities generated at the growth center. Preliminary work by Berry (1968a, 1970a, 1970b, and 1973a; Berry and Niels, 1969) suggests that commuting is a major force effecting spread. In a series of studies, Berry attempted to empirically test the hypothesis of growth center impact via the labour market in metropolitan cities throughout the United States. The findings of these studies showed that:

> varying rythmically with the degree of participation in metropolitan labour markets were a variety of other variables: population densities, value of farmlands and buildings, income and educational levels, migration rates, patterns of population change, and degree of unemployment. (Berry and Niels, 1969, p. 275).

Commuting, as a vehicle that enables peripheral residents to partake in employment opportunities generated at the growth center, is therefore a major determinant of development levels throughout the growth space. The relation between commuting and various measures of development underscores the importance of the spread effects of commuting, leading Berry to conclude that

> the degree of metropolitan labour market participation is the key variable in the 'regional welfare syndrome', indexing the gradient of urban influence over the surrounding area. (Berry, 1970b, p. 3).

In another series of studies, Mosely (1973b and 1973c) examined the impact of growth centers on spatial patterns of development in rural regions, and not unlike Berry, he determined that areas of *upward transition* were found to exist where the opportunity to commute to regional centers of growth was evident. In a subsequent study of the spatial impact of growth centers, Mosely (1974) presented a comprehensive review of the available evidence relating to processes underlying the spread effects of growth, and concluded that impact via the labour market was the single most important factor effecting spread:

> it is by the direct possibility of employment that growth centers make their greatest contribution to the prosperity of rural residents . . . and the commuting hinterland is the single most important index of the extent of the center's impact. (Moseley, 1974, p. 144).

Detailed work on the spatial impact of growth centers in Georgia has been undertaken by Nichols (1969). Implicit in her definition of a growth center (Nichols, 1969, p. 193) is the critical element of commuting needed to effect spread. Utilizing data on percentage variation in median family income for counties in Georgia between 1950 and 1960, she attempted to index change in per capita income with rising population, both variables being linked to expanding employment opportunities at the various growth centers. By using the spatial pattern of residuals from a regression of change in income upon change in population, Nichols found that disproportionate increases in income clustered around major cities. The extent of these *clusters* was shown to be related to the size of the commuting hinterland around these centers.

B. Lack of Empirical Evidence

The foregoing review of growth center impacts suggests that growth center purchases, diseconomies of scale, industrial filtering, innovation diffusion and migration are relatively insignificant forces or processes effecting spread. In contrast, it has been clearly demonstrated that impact via participation in metropolitan labour markets, as a result of commuting to expanded employment opportunities at the center, is the single most important force effecting spread. Although growth center impact is premised on the existence of spread effects of growth,[8] there have been few attempts to ascertain the spatial pattern of impact on surrounding levels of development:

> the idea is that economic improvement initiated in the growth centers will spread to less urbanized hinterlands . . . but actually we do not yet know much, particularly in quantitative terms, of the way in which a favourable economic effect is propogated from an urban growth center to the surrounding territory or the range and spread of the various impacts. (Hoover, 1969a, p. 352).

This paucity of information about the form or *gradient* of impact is largely attributed to the dearth of empirical studies. Hansen notes that there is "a remarkable lack of studies on whether or not the growth of a growth center does in fact spread to the hinterlands" (Hansen, 1973a, p. 17). In a growth center test of the Milwaukee area, inadequate evidence forced Gaile to conclude that "the concept of concentric spread of growth from a growth center has not been proven" (Gaile, 1973a, p. 12). In a later paper based on a review of seventeen studies using the growth center concept Gaile (1973b) concluded that if a trend of impact was discernable, it was that the magnitude of spread effects was less than expected, limited in geographical extent, or less than backwash effects.

The question of whether or not growth will diffuse outward into the surrounding region comprised the focus of a study by Nichols (1969). She maintained that if in fact there was any evidence to substantiate the existence of spread effects, it was likely to be found by examining the processes by which growth is stimulated in a *natural* center of growth, that is, one in which growth evolved spontaneously. Her findings were, however, inconclusive in that they neither supported nor refuted the existence of spread effects from the major center of growth. Similarly, Moseley's studies of the impact of growth centers on the spatial pattern of development in rural areas led him to conclude that "severe doubts must be cast on the notion that growth impulses . . . trickle down" (Moseley, 1973c, p. 93).

The literature is not only inconclusive but, also conflicting. vonBoventer (1970 and 1973) contends that location relative to an urban center will determine its ability to:

(1) reap the beneficial *spillover* effects of industrial agglomeration, and;

(2) minimize market area overlap and subsequent competition with the growth center.

Spatially, opportunities associated with industrial agglomeration decline over distance from a growth center, while the prospect of developing local markets without direct competition from the center increases over distance. Hence, locations that maximize these two effects have the greatest potential for growth. vonBoventer maintains that there is some intermediate distance from a large urban center at which growth prospects are minimized.

In an earlier study of the spatial aspects of urban growth in the United States, Madden (1956) found that the growth rates of urban centers

declined with distance from a metropolis up to seventy-two kilometers (forty-five miles), grew steadily for the next thirty-two kilometers (twenty miles), and declined again up to one hundred eighty-two kilometers (one hundred fourteen miles), beyond which growth rates were high but unstable. Other examples of conflicting findings include a report by Hart and Salisbury (1965) of relatively high growth rates near metropolitan centers; Hodge (1965) found a greater incidence of decline in these very locations.

The review of literature relating to growth center impact illustrates the dearth of empirical study and paucity of information about the spread effects of growth. These problems are further compounded by the contradictory findings of various impact studies. The limited evidence that is available suggests that:

(1) development in rural areas is increasingly dominated by the impact of expanding and intensifying spheres of urban influence (Lamb, 1975);

(2) there exists a distance-decay gradient of population growth, income levels and other economic indicators of well being, radiating outward from the metropolis (Berry, 1970a, 1970b, and 1973a), and;

(3) spread effects of growth from a growth center derive largely from impact via the labour market (Moseley, 1974), that is, the degree of metropolitan labour market participation is a key variable, indexing the magnitude of growth center impact.

## IV. Hypotheses

Synthesizing the preceding evaluation of the spread effects of growth with the earlier theoretical discussion of the spatial impact of growth centers facilitates the formulation of a series of linked hypotheses that are both relevant and testable in the present context:

(1) Levels of development throughout the growth space are inversely related to distance from Edmonton.

(2) There is a positive relationship between the population of urban centers throughout the growth space of Edmonton and the level of development of these centers.

(3) The form of the growth space is arranged concentrically around Edmonton, wherein an area of *downward transition* characterized by relatively low levels of development lies beyond an *upward transitional* area of relatively high development levels.

(4) The high levels of development found in the area of *upward transition* are confined to the commuting hinterland of Edmonton.

The first hypothesis relates to the magnitude of the spatial impact of Edmonton on levels of development throughout the growth space; for, if it can be shown that development levels are a function of distance from Edmonton, then the spatial impact of the latter will have been proved. The second hypothesis derives primarily from Berry's typology of urban-economic growth in which he maintains that growth is a function of position in the urban hierarchy and, in particular, is related to the population of an urban center (Berry, 1973a). Moseley's research on the hierarchical

aspects of growth center impact also alludes to a relationship between settlement size and propensity to benefit. Although the independent variable population is not a locational variable *per se*, it is of relevance in the present analysis for two reasons. First, population is used to construct an index of spatial interaction in the gravity and potential models.[9] Second, population is an indicator of position in the urban hierarchy, and as Berry and Bourne have pointed out, the latter provides a spatial framework for investigating processes of urban spatial interaction (Berry, 1967, 1970b, and 1973a; Bourne, 1975). The third hypothesis is based on the outcome of the interplay between the forces of backwash and spread that take place in the surrounding growth space. Friedmann's center-periphery model provides the spatial framework for testing the hypothesized form of growth center impact. The last hypothesis follows largely from the work of Berry (1968a, 1970a, 1970b, and 1973a) and Moseley (1973b, 1973c, and 1974), both of whom argue that growth center impact on levels of development in the growth space is the single most important factor effecting spread, and that the computing hinterland is the best overall index of this impact.

## V. Concluding Remarks and Organization of the Thesis

In the present chapter, some of the theoretical and conceptual formulations underlying the organization and operation of urban-economic growth were presented. Growth center impacts and various spread effects of growth were also examined. As well, some of the related empirical

literature was also reviewed. These considerations served as a basis for generating relevant and testable hypotheses relating to factors that explain or account for variations in levels of development in the surrounding growth space of Edmonton. In the next chapter, an attempt will be made to clarify some of the conceptual and semantic confusion besetting the growth center literature. First, the theoretical foundation and conceptual framework of the growth center concept will be presented. Second, various properties of the growth center will be qualified, with the intent of defining the terminology used in the present study.

Chapter Three sets out to investigate patterns and trends of population growth and development in the study area - growth space. First, an overview of general patterns of population growth in Alberta and population growth trends in Edmonton is provided. Second, the study area is delineated, and patterns and trends of population growth and various measures of development of urban centers in the growth space are examined. Finally, evidence relating to the impact of Edmonton on the growth and development of urban centers in the growth space is reviewed.

Chapter Four presents the methodology used to test the hypotheses outlined in the present chapter. Emphasis is placed on the statistical techniques used for constructing an *index of development* to measure development levels of urban centers in the surrounding growth space. The data set used to construct this *index of development* and the measurement of these data are specified. The statistical model and methods of analyses used to test the hypotheses and the variables used in the analyses are

explained. The statistical analysis of the data is carried out in Chapter Five, and the analytical results are presented and summarized. Some of the inherent weaknesses of the study and possible suggestions for improving the statistical models are discussed. The concluding Chapter Six summarizes the major findings of the study and draws the appropriate conclusions. Finally, recommendations for further research are presented.

## Chapter One Footnotes

1. It is critical to distinguish between growth and development: the former involves expansion of the system as a whole, through either the addition of new parts or the increased quantity of existing ones. Growth may precipitate change through substitution of one part of the whole by another or by differential growth rates of the existing parts. The latter involves a particular kind of change in which there is a substantial restructuring of the parts, for example, greater functional specialization of growth or new types or levels of interaction and organization. See Berry, Conkling, and Ray (1976).

   From a different perspective, development can be viewed as the entire process of structural change in economic and social systems, as distinguished from growth, which sets the conditions for expansion of aggregate production and total income. Because the latter encompasses the complex of interdependent change in society as a whole, it subsumes the former (as one of its essential impacts). Moreover, development can be further distinguished from two other similar processes - social change and evolution.

2. Bourne (1974) constructed a similar typology depicting the spatial structure of the urban system through which processes of economic growth operate, distinguishing between the national, regional, and local scale:

1) A national urban system, dominated by the largest metropolitan centers and characterized by a discrete hierarchy;
2) Regional sub-systems, nestled in or oriented toward the largest centers of the national urban system;
3) Daily urban systems, often the center of the regional system, delineating the *activity space* of urban residents (see Friedmann and Miller, 1965) and representing the local area of impact on the surrounding tributary area or hinterland.

3. See Hansen (1971 and 1975a).

4. See, also, Hoover (1969).

5. Although the growth center concept was potentially more dynamic, criticisms were leveled at many French researchers because of their initial preoccupation with providing quantitative measures of inter-industry linkages through Leontif-type input-output models that were essentially static in nature (see Hansen, 1967; Thomas, 1972).

6. Myrdal's terms *spread* and *backwash* are analogous to Hirschmann's terminology of *trickling down* and *polarization* (Hirschmann, 1958, pp. 187-190).

7. Other evidence to support the contention that commuting exerts a favourable impact on the growth and development of surrounding areas derives from the findings of studies by Fuguitt and Thomas (1966), Northam (1969), Borchert (1972), and Lamb (1975).

8. Only those spread effects which have received considerable attention in the growth center literature were reviewed in the present study, and it should be noted that other possible spread effects have been cited. Hale (1967), for example, argues that the mechanism by which

positive spread effects work fall under such classifications as wage differentials, investments in social overhead, and the transportation system.

9. For a review of the gravity and potential models of interaction see Yeates (1974, pp. 124-131); Yeates and Garner (1971, pp. 113-117).

# CHAPTER TWO

## UNDERLYING CONCEPTUAL FRAMEWORK AND PROPERTIES OF THE GROWTH CENTER

### I. Introduction

Since Perroux's initial observations that "growth does not appear everywhere and all at once, it appears in points or growth poles with variable intensities; it spreads along diverse channels and has varying terminal effects for the whole of the economy" (Perroux, 1964, p. 143), the related growth literature has become voluminous. Because the literature is voluminous, a great deal of confusion has arisen over the interpretation of Perroux's original terminology (Misra, 1972; Kuklunski, 1972). Indeed, Perroux's original term *pôle de croissance* - growth pole - has since undergone a variety of different interpretations, resulting in supposedly analagous terms such as development pole and development center (Hermansen, 1970 and 1972), growing points (Hirschmann, 1957) and core regions (Freidmann, 1966).[1] Subsequently, considerable confusion presently surrounds the interpretation of terminology used by various researchers. Darwent, in a critical review of the literature attributes this confusion to,

> an enormous variety of indistinct and ill-defined concepts and notions which have arisen partly from the ambiguity of Perroux's initial formulations, partly from mistranslations from French to English and *vice versa*, and partly from the semantic confusion of many authors. (Darwent, 1969, p. 5).

According to Darwent, the reasons for such confusion can be traced to the

failure by many researchers to distinguish between economic space in which growth poles are defined and geographic space in which they happen to have a location.

The welter of semantic confusion surrounding growth pole theory and the related growth center concept led Hansen to conclude that the literature "is badly in need of a thorough semantic reworking: the concepts and language which characterize it need more precise definition and more consistent usage" (Hansen, 1967, pp. 723-724). Moreover, Hansen concurs with Darwent's contention that the inability to interpret the projection of growth poles in economic space to growth poles in geographic space is the major source of confusion. Hansen claims that there have been few attempts to distinguish between the two types of space. The result is one in which theoretical and conceptual formulations are sometimes employed in economic space, sometimes in geographical space, or sometimes concomitantly in both types of space.

The scope and usefulness of the growth center concept is effectively limited by the fact that it is, as Hansen recently stated, "characterized as an ambiguous concept comprised of loosely related, vague sub-concepts" (Hansen, 1967, p. 723). Although the resolution of problems underlying these "areas of severe confusion" (Moseley, 1973a, p. 143) is an essential prerequisite for developing a comprehensive and unified body of growth center theory, such considerations are beyond the scope of the present study. Nonetheless, these issues bear directly on the use and interpretation of terminology employed throughout this study, and therefore require some

qualification. This will be accomplished, first, by presenting an exposition of the original theoretical constructs set down by Perroux and his counterpart Boudeville, and second, by explicating the interpretation of terminology used in the present study.

## II. Growth Pole Theory

### A. Growth Poles and Economic Space

The growth center concept is a logical outgrowth of the need to provide a spatial dimension to the theoretical and conceptual formulations of growth pole theory. The latter, as originally conceived by Perroux in 1950, and later expanded upon in his now famous article entitled 'Note sur la notion des pôles de croissance', was originally developed as a tool to describe and explain the phenomenon of growth in economic space. In an explication of his theory, Perroux identified three types of economic space:

(1) economic space as defined by a plane;

(2) economic space as a field of forces, and;

(3) economic space as a homogeneous aggregate.

The first of these spaces is defined by:

> the set of relations which exist between the firm and, on the one hand, the suppliers of input (raw materials, labour, capital, power) and, on the other hand, the buyers of the output. (Perroux, 1950, p. 94).

The second space consists of:

> centers (poles or foci) from which centrifugal forces emanate and to which centripetal forces are attracted. Each center,

> being a center of attraction and repulsion, has its proper field, which is set in the field of all other centers. (Perroux, 1950, p. 96).

The third type of space is one in which:

> the firm has, or has not, a structure more or less homogeneous with those of other firms; it belongs to a space where, roughly speaking, one price reigns. (Perroux, 1950, p. 97).

In articulating the theory of growth poles both economists and geographers have seized upon Perroux's second topological abstraction of space whereby space is defined as a field of forces. Implicit in his conceptualization of economic space is the notion that development is essentially polarized in that forces inherent in the development process tend toward a clustering of economic activity and of growth itself. In this regard, Perroux contends that development is unbalanced - it occurs at key nodes that are most conducive to further and, therefore, cumulative growth, from which impulses spread to other objects. These nodes maintain their position of dominance because of their ability to attract and adopt innovation, which Perroux, following from Schumpeter (1934), argues is the driving force of development. Moreover, certain of these nodes or foci, because of their characteristics of dominance - large size, high degree of connectivity, high rates of innovation and adoption, fast growth rate - are so able to dominate the objects with which they interact that they effectively control the latters' rate of development. These dominant nodes Perroux termed growth poles.

The concept of dominance is a key component in Perroux's conceptualization of economic space as a field of forces. The effect of domination:

> consists of an irreversible or partially reversible influence

> exercised by one unit on another. An economic unit exercises this effect by reason of its dimension, its negotiating strength, the nature of its activity, or because it belongs to a zone of dominant activity. (Perroux, 1964, p. 85).

A propulsive firm or industry maintains three basic characteristics of dominance:

(1) it must be relatively large in order to ensure that it will generate sufficient direct and indirect effects to have a significant impact on the economy;

(2) it must be a relatively fast-growing sector, and;

(3) the magnitude of its interactions with other sectors of the economy must be such that a significant number of induced effects will, in fact, be transmitted.

Conditions whereby dominance becomes established are often brought about where inequalities among firms appear, resulting in prolonged and widening disparities due to the process whereby the cumulative effect of dominance insinuates itself. Dominant or propulsive industries make the cities in which they are located the poles of their own region (Hansen, 1967). Poles are conceived as groups or individual firms or industries wherein growth and change, measured in input and output flows, are initiated and transmitted. Development is therefore directly related to the activity at the poles themselves; its transmission is a function of the degree of interconnectivity between the poles.

B. Growth Poles to Growth Centers

It is readily apparent that Perroux's concept of a growth pole

focuses on complex relations in economic space, rather than on specific geographical considerations. Indeed, Perroux refers to geographic space as *banal*. Interpreting Perroux's conceptualization of economic space in spatial terms can therefore be misleading, and should not be confused with the concept of economic space where poles exist in spatial abstraction. Moseley (1974) suggests that conceptual and semantic confusion between economic and geographic space can be avoided by viewing the growth pole model in geographic theory as an analogue model wherein the spatially abstract tenets of growth pole theory are examined to discern whether they provide testable hypotheses that are relevant to the geographical dimension. Moseley maintains that, in this context, nodal locations would be defined as urban areas, and their role in the development process would provide the focus for an inquiry into the degree to which development is unbalanced or concentrated in urban poles or centers of growth. The degree to which these centers dominate their region or hinterland would be contingent upon the presence of conditions of dominance - the extent of their spatial connectivity, their size, growth rate, and propensity to adopt innovation. In addition, the channels by which *growth impulses* are transmitted from nodes or centers to their region will also determine the degree of dominance exerted by these centers.

If growth pole theory is to be viewed as an analogue model for spatial analysis, any parallels between growth pole theory in geographic space and economic space must be treated as preliminary or unproven theoretical constructs, for Perroux's work does not by itself provide a good basis for investigating the spatial aspects of growth pole theory. The growth

pole concept, when applied as a theory of location in geographic space for firms, industries or cities must rely on traditional theories of location and spatial organization (Hermansen, 1970) as well as theories of external economies of agglomeration and inter-industry linkage. Accordingly, Paelinck (1965) concludes that growth pole theory, when applied at a geographical level, should be regarded as a *conditional* theory of regional growth that establishes the conditions or preconditions under which accelerated regional economic growth may take place.

C. Growth Centers and Geographic Space

Growth pole theory, *a priori*, does not provide guidelines for the location of propulsive firms or industries in geographic space, nor of their locational consequences; the interaction between such units and their subservient counterparts is seen only in relation to a theoretically spaceless economy. Although Perroux's threefold typology is largely responsible for reshaping perceptions of the economic growth process, it has been criticized by both geographers and economists because of a lack of emphasis placed on the importance of spatial considerations. Specifically, criticism is focused on Perroux's outright dismissal of the spatial aspects and implications of economic growth. The initial application of growth pole theory in a specific geographic context was first attempted by Boudeville (1966), who, unlike Perroux, stressed the regional character of economic space. The tendency toward or creation of clusters or poles of economic activity in certain areas or centers, Boudeville argued, is nowhere more clearly demonstrated than in geographic space. The

transformation from economic to geographic space is made possible by the distinction between space and region; the latter is a contiguous geographic area whereas the former is not. Following from Perroux, Boudeville maintains that, from an economic viewpoint, there are three types of space: *homogeneous*, *programming*, and *polarized*. The homogeneous space corresponds to a continuous space in which relevant properties maintain similar characteristics. The programming or planning region is considered to be a space whose various parts are placed under one authority.

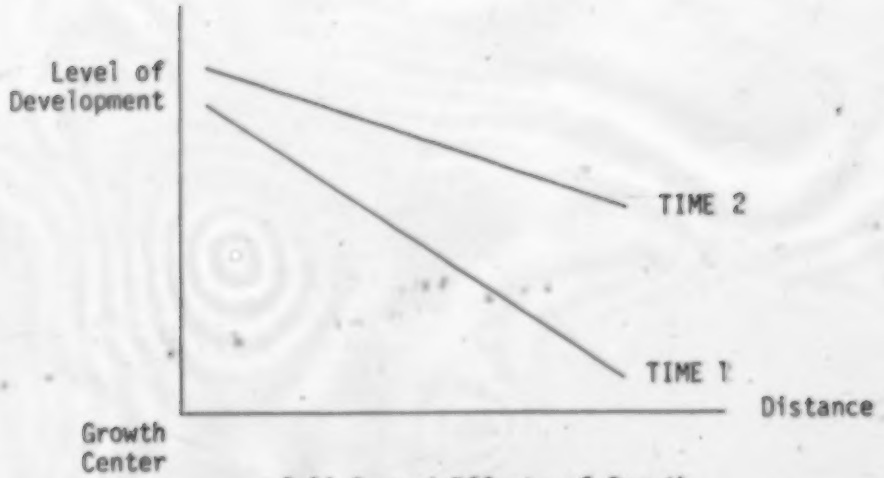
In contrast, the notion of polarized space is viewed in terms of interdependence between components and is closely related to the hierarchical ranking of urban centers - components, and their interrelations. The polarized region is defined as a heterogeneous but contiguous entity of complementary and interdependent components, functionally integrated with a dominant urban center or pole, between which a greater degree of interaction or exchange takes place than with any other center. The spatial extent of the polarized region is the point or line beyond which interactions are orientated toward some other pole. Since the polarized region can be expressed in terms of polarized space, poles are said to exist at a local, regional and national scale, giving rise to a nestling of smaller poles within larger ones. Moreover, each pole has a location in regional economic space and is therefore conceived as a center of polarization, exhibiting characteristics of dominance that lead to the generation of growth *impulses*. In this regard, poles that exist in regional economic space and maintain characteristics corresponding to growth poles are termed growth centers.

D. Possible Growth Center Impacts

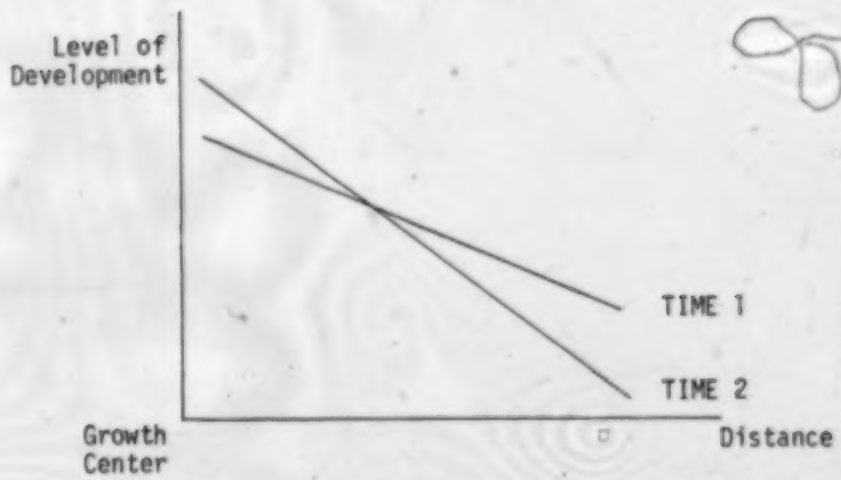
Implicit in Perroux's concept of dominance, a central tenet of growth pole theory, is the notion of impact. Boudeville maintains that, in a spatial context, urban poles or centers of growth exhibit characteristics of dominance such that they exert a commanding influence on the surrounding areas with which they interact. The outcome of these impacts is, however, far from clear. On the one hand, Myrdal (1957) suggests that the process of *circular and cumulative causation*, whereby factors of production such as capital and labour are drawn from periphery to center, reinforces the dominant position of the center of growth. This effect, whereby inequalities of growth between center and periphery are accentuated, is termed *backwash* by Myrdal. On the other hand, Hirschmann (1958) contends that processes underlying a position of dominance that give rise to initial disparities of growth inevitably result in the spread of growth and erosion of dominance. The effect of this spread of growth is one in which inequalities of growth are narrowed. In essence, it is the interplay of these opposing forces of backwash and spread that, to a large degree, determine the form and magnitude of impact on levels of development in the growth space. Size, as an important characteristic of dominance, is also a key determinant in the generation of impact (Perroux, 1955; Hansen, 1967). Boudeville (1966) notes that characteristics of dominance and subsequent effects exerted by the dominant node or center become more evident and pronounced at higher levels of the urban hierarchy, and it is therefore hypothesized that the outcome of these impacts is

FIGURE 2-1

GROWTH CENTER IMPACTS




2-1A Spread Effects of Growth




2-1B Backwash Effects of Growth

Adapted from Moseley (1974), p. 120.

largely a function of the population of an area or center and its distance relative to the dominant center.

The effects of spread and backwash over time on levels of development at varying distances from the growth center are depicted in Figure 2-1A and 2-1B. These figures "express diagramatically the hypothesis that 'spread' effects emanating from growth centers normally outweight any 'backwash'" (Moseley, 1974, p. 119). When spread effects predominate, over time, levels of development become more spatially even (Figure 2-1A); conversely, when backwash effects prevail, spatial variation of development levels widens.

## III. Interpretation of Growth Center Terminology

Before testing hypotheses relating to those factors underlying variation in levels of development throughout the growth space of Edmonton, however, it will be useful to address problems of semantic confusion besetting the growth center literature. In this regard, the work of Moseley (1973a, and 1974) is instructive because he was able to place these problems in perspective by identifying a number of contentious issues giving rise to areas of confusion in the literature. The salient aspects of these issues will be presented in the next section with the intent of focusing on various properties of the growth center concept and explaining the interpretation of terminology used in the present study, for purposes of maintaining conceptual clarity and a degree of internal consistency of usage.

A. Growth and/or Centrality

One issue relates to the nature of the term *growth center*; the uses and emphasis of these terms in the literature are many and varied. Centrality or nodality can be measured by various indicies of connectivity and accessibility (Kansky, 1963), or by the function, range, and level of services provided in a central place hierarchy (Christaller, 1966). The treatment of the term growth, on the one hand, involves the type of growth for, "if growth is intrinsic to the (growth center) concept, then growth of what" (Moseley, 1974, p. 11). Although growth in employment, industrial output, population, retail sales, housing construction, and gross or per capita income are common measures of growth, some authors do not use explicit measures of growth but, rather, treat growth in a general sense. On the other hand, appropriate ways of measuring growth and changes of growth are important in that different patterns are likely to emerge on the basis of a decision to measure growth in relative or absolute terms. If, as is so often the case, rates of change rather than absolute increments of change are being measured, two additional factors must be considered. One involves the selection of a base-line such as a regional or national average for which to compare relative rates of growth; the other necessitates somewhat of an arbitrary decision for determining the amount by which growth rates exceed those of the base-line.

In addition to some of the different uses for and measurements of the terms centrality and growth, there is no concensus among growth center researchers as to the relative importance of these terms. Some authors

emphasize centrality (Fox, 1966; Bylund, 1972; Misra, 1972), some stress growth (Nichols, 1969; Casetti, et.al., 1971; Lewis and Prescott, 1972), while still others incorporate aspects of both (Boudeville, 1966; Hodge, 1966; Allen and Hermansen, 1968; Kuehn and Bender, 1969; Robinson and Salih, 1971).

Since a major component of the present study focuses on the impact of Edmonton on the form of development levels in the surrounding growth space, aspects of both centrality and growth are important. The former relate primarily to proximity or accessibility to Edmonton as measured by distance; the latter encompasses a wide range of development measures used to index overall levels of development in the surrounding growth space. Finally, change or growth is expressed in a manner consistent with the particular composition of each variable.

B. Positive or Normative

A second issue revolves around the concept of a growth center; two approaches are considered. On the one hand, the growth center can be a *positive* concept, helping to explain and predict events and occurrences that have taken, are taking, or might take place. On the other hand, the growth center concept can be viewed as being essentially *normative*, in that it can be used as an instrument to prescribe policy guidelines to achieve acceptable or desired growth rates and distribution of population, economic activity, income and so forth. The present study does not address policy-related issues but, rather, focuses on postdicting factors underlying variation in development levels throughout the growth space of Edmonton;

a positive approach is therefore adopted.

C. Temporal Aspects of Growth

A third issue concerns the temporal aspects of growth. First, there is the question of the timing of growth - "Are we speaking of places or phenomena that have grown, that are growing, that are predicted to grow, or that (in a normative sense), we wish to see grow in the future?" (Darwent, 1969 p. 5). In this instance, data availability necessitates a historical examination for empirical purposes. Second, there is the question about the duration of growth, that is, "How long must a place grow in order to earn growth center status?" (Moseley, 1974, p. 12). In this regard, the designation of Edmonton as a growth center is justified, rather than assumed, and the criteria upon which this designation is based is presented in the following chapter.

D. Size

A fourth issue relates to growth center size, and once again, the literature is not only inconclusive but, also, contradictory. Resolution of this issue is important because it is hypothesized that there is a relationship between growth center size and the form and magnitude of impact (Berry, 1970a; Moseley, 1974). Whereas most researchers argue that the population of an urban center must fall within a specified size range to qualify as a growth center (Fox, 1966; Allen and Hermansen, 1968; Berry, 1970a, 1970b, and 1973a; Hansen, 1971, 1975a, and 1976), others do not consider size to be an important criterion upon which growth center

designation is based (Boudeville, 1966; Hodge, 1966; Bylund, 1972). Still another researcher refers to a hierarchy of growth centers corresponding to the existing hierarchical arrangement of the urban system (Misra, 1972). Regardless of whether a range or size of growth center is specified, there exists a wide variation in the actual size of growth centers selected for empirical study. Friedmann (1966), for example, treated the *core* region of Caracas, Venezuela, with a population of 1,336,000 in 1961, as a growth center, while Casetti, et.al. (1971) examined the impact of the growth center of Los Angelos - population, 2,479,000 in 1960, on the growth rates of twelve other urban centers within 1,000 miles.[2] In contrast, a study by Carol (1966), in which he attempted to identify growth *poles* in Southern Ontario using various indices of centrality, examined urban areas with populations of less than 15,000.

Perhaps the most comprehensive effort to apply a program predicated on the growth center concept was attempted by the United States Economic Development Administration[3] (Hansen, 1971 and 1973a). The program, designed to raise welfare levels of Appalachian residents through government investment in *potential* areas of growth, selected 171 centers in which to disperse funds for economic assistance and stimulation. The apparent failure of the program has largely been attributed to its policy of dispersed assistance to small urban centers - over one-half of the funds were placed in towns with less than 5,000 residents. Indeed, Berry has pointed out that "an examination of the *gradients* of urban influence of smaller centers indicates clearly that there seems little sense in trying to use small urban places as growth centers - their regional influence is too limited" (Berry, 1967,

p. 12). The rationale underlying this argument is that there are relatively few kinds of economic activities which can operate efficiently in such small communities and that investments should therefore be placed in those urban centers with the greatest potential for self-sustaining growth.

Self-sustaining growth generally relates to some critical population size "beyond which absolute contraction is highly unlikely, though the growth rate may slacken, at times even to zero" (Thompson, 1965, p. 22). This notion is termed the "size-ratchet" effect by Thompson, where past growth is "locked-in" by urban expansion. Thompson cites a number of reasons underlying the "size-ratchet" effect. First, size generally gives rise to diversification, thereby decreasing the likelihood of fluctuations and decline. Second, it creates a large local market that requires a range of goods and services. Third, it provides the necessary infrastructure for both basic and non-basic activities. Fourth, it attracts a large pool of skilled labour and entrepreneurship.

A growth center strategy focused on centers of self-sustaining growth raises a number of questions regarding size necessary to achieve self-sufficient growth. Nichols (1969), in a study of growth center impact incorporates the criterion of self-sustaining growth in her concept of a growth center. However, because self-sustained growth is considered to be a function primarily of urban size (Berry, 1973a), the use of this criterion is questionable. Moreover, the relationship between self-sustaining growth and urban size implies a critical size threshold (Berry, 1970a), beyond which a stable rate of growth is assured. The *critical*

threshold required before such growth is thought to take hold is subject to debate. In constructing a set of Functional Economic Areas for the entire United States focusing on urban centers of approximately 25,000 or more, Fox (1966) argued that such foci were of a large enough size around which economic activity and population could be organized. However, studies by Berry and Niels (1969), Berry (1973a), and Moseley (1973b) suggested that a figure of 25,000 was likely the minimum size below which no appreciable impacts on surrounding levels of development could be discerned. In addition, evidence on the spread effects of growth within the commuting hinterland (Berry and Niels, 1969; Berry, 1970a, 1970b, and 1973a; Moseley, 1973c and 1974) indicated that a population of 25,000 appeared to mark a possible discontinuity below which discernible spread effects were insignificant. Berry and Niels found that whereas metropolitan influences gave rise to well-marked gradients of urban orientation, "Urban centers with a population of less than 25,000 generally have no local impact of the gradients" (Berry and Niels, 1969, p. 275).

In contrast, a study of population growth rates of Standard Metropolitan Statistical Areas[4] in the United States by Berry (1970, 1973a, and 1973b) indicates that metropolises of greater than 1,000,000 exhibited stable population growth rates similar to the national average, and that below this figure, fluctuations in growth rates became more pronounced. Berry then proceeded to modify the Standard Metropolitan Statistical Area as a basic unit of urban analysis to construct an alternate unit of spatial accounting called the *Daily Urban System.*[5] Although these *Daily Urban Systems* were

conceptually similar to Fox's *Functional Economic Areas* in that both schemes divided the coterminious United States into urban spheres of influence, there are two essential differences. First, Berry's delineation was based on his previous empirical analysis of commuting patterns around existing economic centers, while Fox used the criterion of economic activity linkages. Secondly, the focal points for the set of *Daily Urban Systems* are large urban centers of close to or greater than 1,000,000 whereas the *Functional Economic Areas* centered on cities of approximately 25,000.

Notwithstanding these extreme threshold estimates, most threshold analysts agree that self-sustaining growth sets in in the range of 200,000 to 500,000 (Friedmann and Miller, 1965; Shackleford, 1970; Hansen, 1971 and 1973a; Klaassen, 1973; Morrill, 1973; Moseley, 1974; Lamb, 1975). Indeed, Berry, found that, in general, "labour markets appear to need to be greater than 250,000 population to be viable parts of the urban system" (Berry, 1967, p. 14). Recently, a nationally exhaustive set of regions, corresponding to *Daily Urban Systems*, was developed by the Bureau of Economic Analysis, United States Department of Commerce. These regions were defined on the basis of earlier commuting studies by Berry. Each of the 171 regions focused on an urban center with a population of 200,000 or more.

In addition to considerations of threshold size, there is the related topic of *optimal* growth center size. Whereas the former implies some minimum size beyond which self-sustaining growth sets in, the latter focuses on the *best* or most favourable size required to achieve such growth.

Although the question of optimality has been extensively examined elsewhere (Shindman, 1955; Duncan, 1957; Klaassen, 1965; Neutze, 1967; Allen, 1968; Alonso, 1968a, 1968b, and 1971; Von Boventer, 1970 and 1973; Richardson, 1972 and 1973a) and need not be detailed here, two points are worthy of mention. First, it is argued that the question of optimal size is, at present, of doubtful value, given the existing limitations and restrictions of the poorly developed theoretical framework upon which the growth center concept is based. Secondly, questions of optimal size are essentially normative in that they are primarily concerned with determining the best size required to achieve self-sustaining growth, based on a set of preconditions such as industrial structure or mix, capital investments, urban infrastructure and so forth. This inherent normative element raises a number of policy-related problems and questions that are not addressed in the present study because such issues would only serve to shift the emphasis away from attempts to postdict variations in levels of development throughout the growth space of Edmonton. This, coupled with the poorly developed theoretical basis of the growth center concept precludes further considerations of questions of optimal size. The question of threshold size, however, will be examined in the ensuing chapter in an attempt to provide an indication as to whether Edmonton, given its size and growth rate, can be considered to have reached the threshold of self-sutaining growth.

E. Areal Extent

A fifth issue relates to the spatial delineation of growth center location in geographic space. Two possible approaches are considered. One approach distinguishes between the built-up urban area - the growth center, on the one hand, and the area of spatial impact - the hinterland, on the other hand. A second approach defines the spatial extent of the growth center according to the employment hinterland. While the former approach does not appear to be consistent with the reality of the evolving urban system, it is preferred for two reasons. First, it can be argued that the criterion of employment or journey-to-work used to delineate the hinterland is arbitrary in that other criterion such as retail expenditures, migration patterns, or inter-industry linkages may better serve the same purpose. Moreover, the selection of a cut-off point for the criterion used to measure the extent of the hinterland is also arbitrary. Second, regardless of how hinterland is defined, "there is a danger of prejudging hypotheses which relate to the ability of growth centers to transmit development impulses to their hinterland" (Moseley, 1974, p. 12). Since the present study is primarily concerned with measuring and examining the impact of Edmonton on development levels in the surrounding growth space, the first approach outlined above is employed, regardless of its systematic inadequacies.

F. Potential *versus* Spontaneous Growth

In a study of the merging patterns and shifts of changing population

growth and distribution in the American urbanization phenomenon of the twentieth century, Alonso and Medrich argue that:

> a national urbanization policy, as an element of a national urban policy, should address itself to the issues of efficiency or development, as manifested in growth centers that may be termed spontaneous, as well as to questions of equity through inducing growth in centers where the overall functioning of the system is not producing it. (Alonso and Medrich, 1972, p. 229).[6]

Alonso and Medrich distinguish between two types of growth centers: on the one hand, "induced growth centers are those in which public policy is trying to promote growth"; while, on the other hand, "spontaneous growth centers are those that are growing without benefit of special assistance, or at least without benefit of conscious or explicit policy" (Alonso and Medrich, 1972, p. 230).

Initially, the growth center concept was concerned primarily with inducing growth in potential centers of growth as a means of diverting growth from congested cities or spontaneous growth centers to *lagging* areas, in an attempt to effect a more even distribution of population and resources. The general failure of these growth center related policies (Hansen, 1971 and 1975; E.F.T.A., 1973) in achieving goals of growth decentralization or deconcentration has led to recent research efforts focusing primarily on centers of spontaneous growth. In commenting on these recent changes in the thrust and direction of growth center research Hansen makes the point that,

> While there is, of course, nothing wrong *per se* with positive analyses of spontaneous growth centers, they do shift the ground from the major (normative) issues that originally were the main *raison d'etre* for the growth center notion. (Hansen, 1975b, p. 822)

This shift in emphasis - from essentially normative concerns about potential centers of growth to positive approaches to spontaneous growth centers - has evolved in response to the need for a better understanding of the processes that underlie spontaneous growth. For, if growth is to be induced in traditionally *lagging* areas, it is necessary to ascertain the ways in which such growth can be stimulated. According to Alonso and Medrich:

> It would seem worthwhile to study the characteristics of such centers and the importance of their role in national urbanization, both for the lessons they may hold for inducing growth where it does not occur spontaneously and for their own sake as a valid subject of national developmental policy, since growth also has its problems. (Alonso and Medrich, 1972, p. 230).

The present study focuses on the impact of Edmonton, as a growing center of population, on development of the surrounding growth space.

## IV. Summary and Concluding Observations

In this chapter, two interrelated aspects of the growth center concept were examined in an attempt to introduce some semblance of order to a literature that is characterized by areas of severe conceptual and semantic confusion. First, the evolution of the growth center concept, from initial formulations of growth pole theory, was traced, focusing on the projection of growth poles in economic space to growth centers in geographic space. This conceptual *jump* from economic to geographic space was important because it provided a spatial context for examining the spatially abstract constructs of growth pole theory. Second, an assessment of various growth center

properties and an interpretation of growth center terminology was undertaken. This review was intended to explicate the terminology used throughout the present study in an attempt to avoid, or at least minimize, problems of semantic confusion that are so prevalent in the growth center literature.

Despite preliminary research findings relating to the nature of forces that give rise to spread effects of growth, there is still considerable disagreement among researchers as to the selection of relevant criteria for determining growth center size, the nature or type of growth, the spatial extent of growth centers and levels of accessibility of the growth center to the surrounding areas. Moreover, when similar criteria are used, these are often measured in different ways. Such problems are further compounded by the fact that some researchers focus on centers of potential growth while others talk about spontaneous growth centers. These issues remain unresolved largely because not enough is known about existing and past patterns of change. This lacuna in the growth center literature derives mainly from the poorly developed theoretical framework and the subsequent dearth of empirical study. Thus, it is argued that an historical examination of growth is essential if these outstanding problems besetting the growth center literature are to be satisfactorally resolved.

## Chapter Two Footnotes

1. Perroux and the French 'school' of regional economics use the terms *pole* and *polarization* in a different context than does Hirschmann and his English counterparts. The former define a pole as a clustering or concentration of elements in both abstract and geographical space; polarization is used to denote the process by which poles, as defined above, change spatially and structurally over time. The latter define polarization as the process by which two extremes attract the elements between them. Accordingly there will normally be two poles, whereas in the French context, there can be more than two. For further reference on this point, see J.R. Lawsen (1969). Higgins provides a useful distinction between *poles de croissance* - growth poles and *poles de developpement* - development poles. The former can be defined as "fast-growing urban centers that are strong reactors to growth generated elsewhere"; the latter is defined as "strong generators of spread effects to the whole . . . economy" (Higgins, 1972, p. 226).

2. The twelve other urban centers ranged in population from about 100,000 to over 1,000,000 in 1960.

3. The Economic Development Administration (EDA) is responsible for providing development aid to designated multistate *redevelopment areas* and to assist the regional commissions administering to these areas. In 1966, five regional commissions were established, modelled on the existing Appalachian Regional Commission (ARC), to oversee redevelopment in the Ozarks, the Coastal Plains, the Upper Great Lakes, and New England. Some of these regional commissions have formulated growth center strategies (see, in particular, Berry, 1968, and Hansen, 1971, 1973a, and 1973b).

4. A Standard Metropolitan Statistical Area (SMSA) is a spatial unit of measurement and analysis analogous to the Census of Canada Census Metropolitan Area. An SMSA is defined as a county or group of contiguous counties (except in New England) which contains at least one city of 50,000 inhabitants or more, or "twin cities" with a combined population of at least 50,000. Other contiguous counties are included in an SMSA if, according to certain criteria, particularly levels of commuting they are essentially metropolitan, in that they are socially and economically integrated with the central city. In New England, towns and cities, instead of counties, are used in defining SMSA's. (See U.S. Department of Commerce, Bureau of the Census, Characteristics of the Population, Vol. 1, Part 1-52, February, 1973, Area Classifications, Appendix A-6.)

5. The term *Daily Urban System* was first coined by Doxiadis (1969).

6. For further discussion on the issue of equity *versus* efficiency see Alonso (1968b), Higgins (1972), Hagerstrand (1972), Mera (1973), E.F.T.A. (1973), Bourne (1975).

# CHAPTER THREE

# PATTERNS AND TRENDS OF GROWTH AND DEVELOPMENT IN THE GROWTH SPACE OF EDMONTON

## I. Introduction

Population data, despite their shortcomings, provide a useful starting point for examining variations in levels of development. The distribution and pattern of population and changes in population growth rates are commonly used indicators of development trends (Haggett, 1975). Since these development trends are likely to manifest themselves in some of the many ways by which population can be measured, an examination of recent population data would be helpful within the context of the objectives of the present study.

The purpose of the present chapter is to provide an overview of recent patterns and trends of population distribution and development. First, general population growth patterns and trends in Alberta and metropolitan Edmonton are examined. Second, the study area - growth space - is delineated and the selection of urban centers in the growth space is discussed. Third, patterns of population distribution and growth trends of urban centers throughout the growth space are examined. Fourth, various measures of development are investigated to ascertain the magnitude of their variation throughout the growth space, and to determine the degree to which they parallel similar patterns and trends evidenced in the population data.

## II. General Population Growth Patterns and Trends

### A. Alberta

The population of Alberta, not unlike the rest of Canada, has become increasingly urbanized during the decade of 1961 to 1971. Whereas the average annual population growth rate of the province during this period was 2.2% overall, the urban population grew by 4.2%.[1] The rising level of urbanization is illustrated by the increased proportion of the population residing in urban centers: in 1961, 63.3% of the population was classified as urban and by 1971 this proportion had increased by 16% to 73.5%.[2] Although the majority of the urban population was concentrated in the two metropolitan centers of Calgary and Edmonton, their combined average annual growth rate of 4.2% between 1961 and 1971 was actually less than the corresponding overall rate of 4.7% for smaller urban centers of less than 30,000.[3] The distribution of these urban centers and their respective growth rates are presented in Figure 3-1. Four resultant patterns of high growth urban centers are discernible:

(1) All eight centers in the northwest central part of the Province, focusing on the Peace River District;

(2) All five urban centers in the northeast central part of the Province, bordering the Athabasca Tar Sands Region;

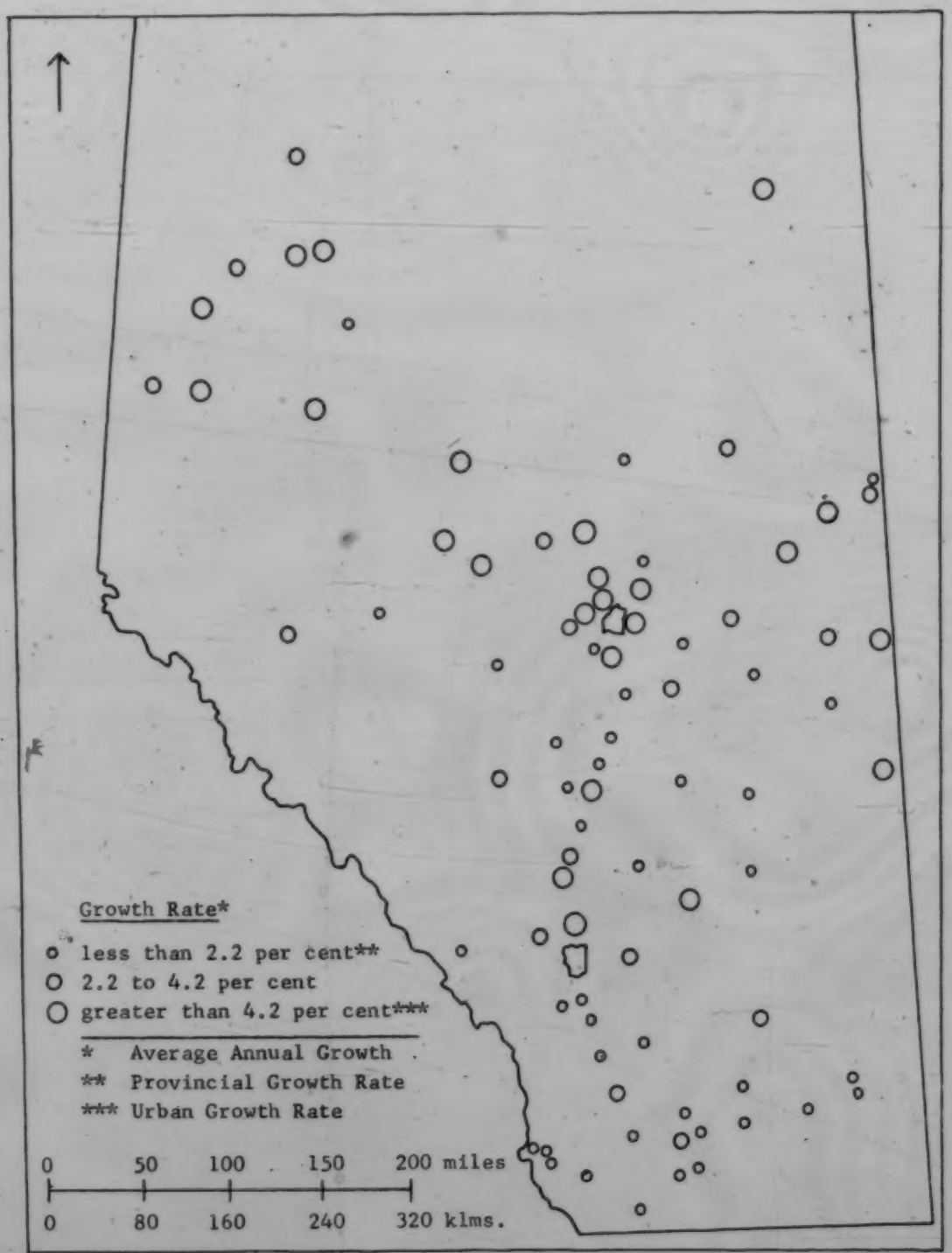
(3) A linear string of three urban centers north of Calgary, and;

(4) A clustering of eight urban centers around Edmonton.

Of particular relevance in the present context is the latter and most prominent pattern of high growth urban centers clustered around Edmonton.

Figure 3-1

Patterns of Population Growth in Alberta


Growth Rate*
less than 2.2 per cent**
2.2 to 4.2 per cent
greater than 4.2 per cent***
* Average Annual Growth
** Provincial Growth Rate
*** Urban Growth Rate
0 50 100 150 200 miles
0 80 160 240 320 klms.

Source: Census of Canada, Population: Census Subdivisions (Historical), Catalogue 92-702, Vol. 1, Part 1, (Bulletin 1.1-2), July, 1973, pp. 2-106 to 2-109.

Patterns and trends of population growth around Edmonton are examined in detail in the next section.

B. Edmonton Census Metropolitan Area

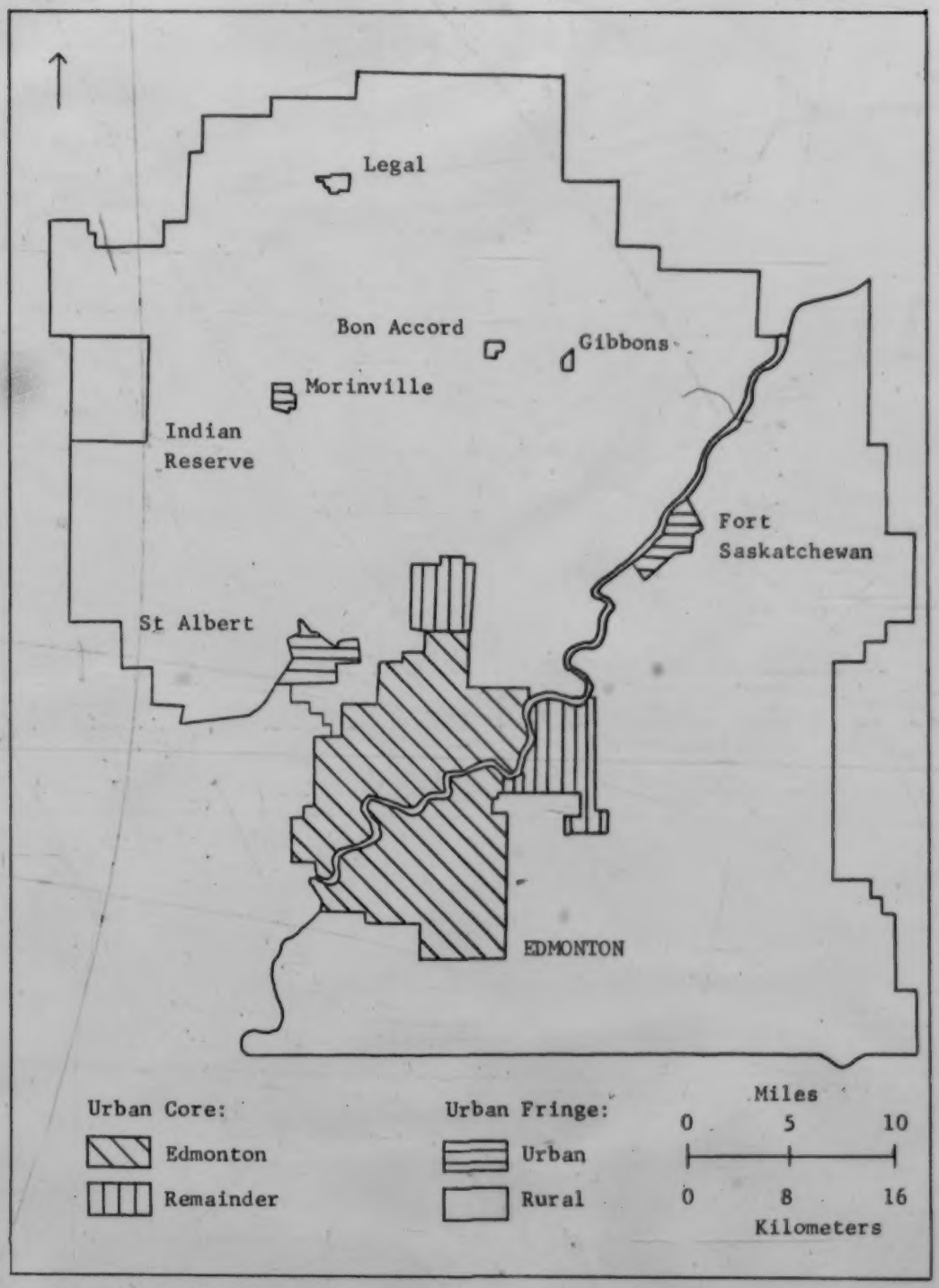
Edmonton is one of the fastest-growing metropolitan centers in Canada. During the decade of 1961 to 1971 the central city[4] of Edmonton experienced an average annual growth rate[5] of 3.6%, compared to a corresponding provincial growth rate of 2.2% and a national growth rate of 1.8%[6] This rate of growth was the third highest recorded by a central city, and placed Edmonton's central city population of 438,152 in 1971 third behind only Montreal and Toronto.

A more complete account of the population growth of Edmonton can be found by examining population changes in the Census Metropolitan Area[7] (Figure 3-2). Overall growth rates between 1961 and 1971 rose by about 4.7%, compared to a central city growth rate of 3.6%, suggesting that an increasing proportion of the population growth is taking place in areas adjacent to the central city. This supposition is borne out by closer examination of changes in the growth rates of the central city and Census Metropolitan Area during the inter-censal decade (Table 3-1). The former witnessed a slight decline in the growth rate after 1966 from 3.4% to 3.2%, whereas the latter exhibited a marked increase in the growth rate for the same periods from 3.8% to 4.7%. Population growth rates of the fringe area - that part of the Census Metropolitan Area excluding the central city[8] - also support the contention that areas beyond the

Figure 3-2

Edmonton Census Metropolitan Area





central city are not only growing at a relatively faster rate but, also, at a more accelerated rate (Table 3-1). Although the total population of the fringe comprised only a small proportion of the Census Metropolitan Area population, relative rates of change of population growth after 1966 more than doubled - from 11.8% to 27.2%. Moreover, the overall increase of 25.6% for the entire decade was significantly higher than corresponding rates of population growth both for the central city and Census Metropolitan Area as a whole.

A different perspective of shifting population patterns is provided by examining changes in the proportion of population residing in both the central city and urban fringe of the Census Metropolitan Area. Table 3-2 shows that the proportion of the Census Metropolitan Area population residing in the central city declined by 7.4%, from 95.4% in 1961 to 88.4% in 1971. Conversely, change in the proportion of the population living in the fringe increased by 157.8% between 1961 and 1971 from 4.5% to 11.6%.

Based on the foregoing evidence, it is apparent that not only are growth rates of the fringe greater than those of the central city, but also, that changes in these growth rates are increasing at an accelerated rate in the fringe while showing a slight decline in the central city. The changes evidenced by the shifting population patterns and rates of growth are reflected by the increased proportion of Census Metropolitan Area residents that live beyond the central city. These preliminary observations point toward a trend of increasing population growth in areas

Table 3-1

Population and Population Growth of Metropolitan Edmonton: Census Metropolitan Area, Central City and Fringe, 1961, 1966, 1971

| | Population | | | Population Growth* | | |
|---|---|---|---|---|---|---|
| | 1961 | 1966 | 1971 | 1961-66 | 1966-71 | 1961-71 |
| Central City[9] | 322,238 | 376,925 | 438,152 | 3.4 | 3.2 | 3.6 |
| Fringe | 15,330 | 24,374 | 57,550 | 11.8 | 27.2 | 25.6 |
| C.M.A. | 337,568 | 401,299 | 495,702 | 3.8 | 4.7 | 4.7 |

* Average Annual % Change

Source: Census of Canada, Population: Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Catalogue 92-708, Vol. 1, Part 1, (Bulletin 1.1-8), January, 1973, p. 8-1.

Table 3-2

Proportion of Population and Change in the Proportion of Population in Metropolitan Edmonton: Census Metropolitan Area, Central City and Fringe, 1961, 1966, 1971

| | Proportion | | | % Change in Proportion | | |
|---|---|---|---|---|---|---|
| | 1961 | 1966 | 1971 | 1961-66 | 1966-71 | 1961-71 |
| Central City | 95.5 | 94.0 | 88.4 | -1.6 | -6.0 | -7.4 |
| Fringe | 4.5 | 6.0 | 11.6 | 33.3 | 93.3 | 157.8 |
| Census Metropolitan Area | 100.0 | 100.0 | 100.0 | - | - | - |

Source: Adopted from - Census of Canada, Population: Cities, Towns, Villages, Census Metropolitan Areas and Census Agglomerations, Catalogue 92-703, Vol. 1, Part 1, (Bulletin 1.1-8), January, 1973, p. 8-1.

beyond the central city or core of Edmonton. To ascertain the extent and magnitude of population growth, both within and beyond Edmonton, an overview of population trends in the study area - growth space - is required. The following section outlines the study area, and then proceeds to examine in detail population growth rate patterns throughout the study area.

## III. The Study Area

The area of study - growth space - extends outward about 150 kilometers (90 miles) from Edmonton, or approximately two hours driving time. The growth space, often referred to as the urban field (Friedmann and Miller, 1965), for purposes of this study, is defined as the area in which there is the greatest potential for daily interaction between a metropolitan center - Edmonton - and its surroundings. In the present context, daily interaction is when round-trip to Edmonton is completed on the same day, on a more or less regular basis. Following from Robinson and Salih (1971), only those settlements classified as urban[10] are selected for investigation, each center being a sample point in the growth space.

### A. Population Growth Patterns and Trends in the Growth Space of Edmonton

Twenty-two urban centers are located within the growth space of Edmonton[11] (Figure 3-3). Table 3-3 contains the population and average annual growth rate of these centers for the years 1961, 1966, and 1971, and their distance from Edmonton. An examination of their population growth rates between 1961 and 1971 reveals that the highest rates of growth occurred in the three urban centers closest to Edmonton - Sherwood

Table 3-3

Population, Population Growth and Distance from Edmonton of Urban Centers in the Growth Space, 1961, 1966, 1971

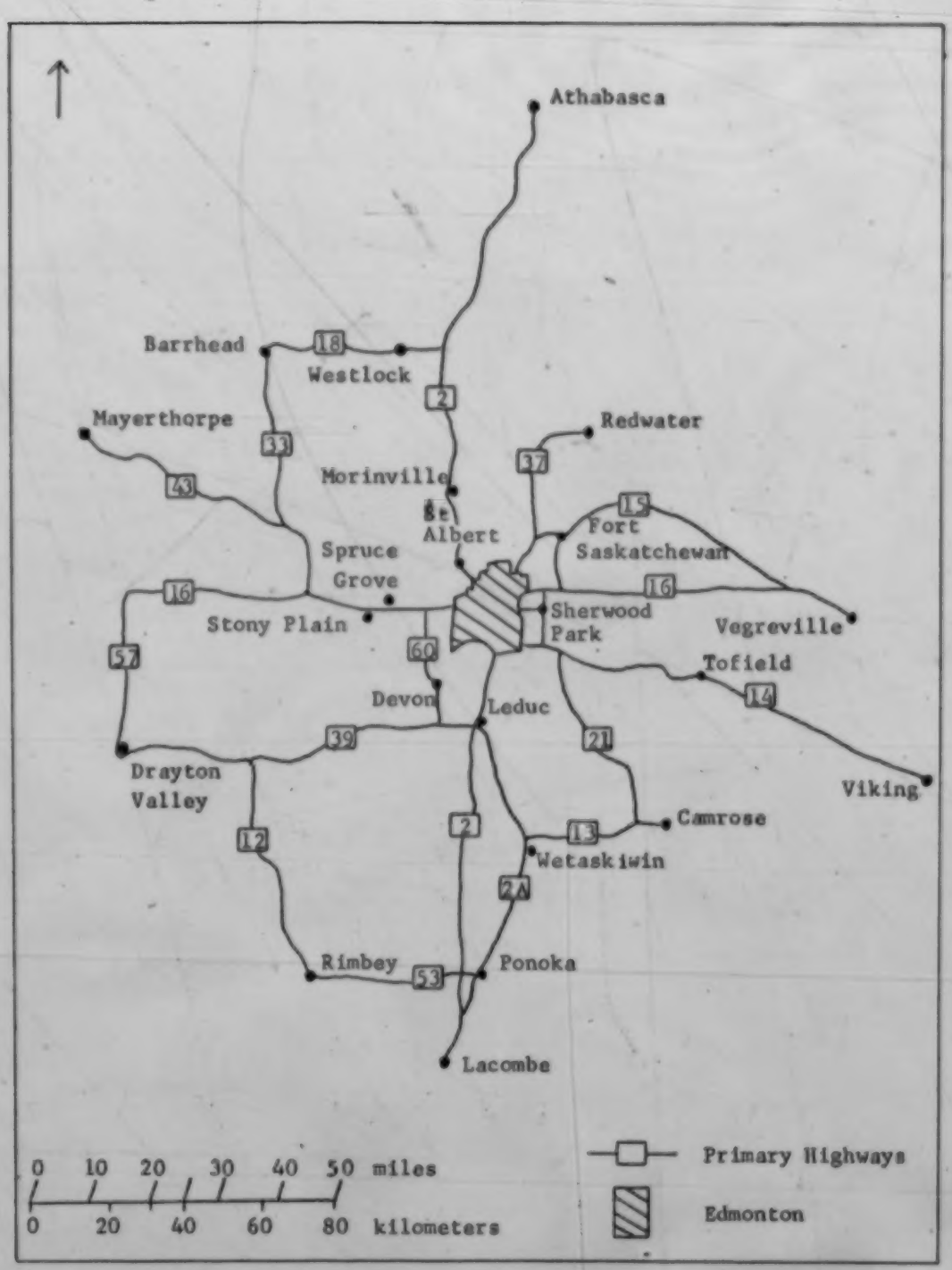
| Urban Center | Population | | | Population Growth* | | | Distance** (Kilometers) |
|---|---|---|---|---|---|---|---|
| | 1961 | 1966 | 1971 | 1961-66 | 1966-71 | 1961-71 | |
| Sherwood Park | 2923 | 6339 | 14282 | 23.2 | 25.1 | 38.8 | 14.4 |
| St. Albert | 4059 | 9736 | 11800 | 28.0 | 4.2 | 19.1 | 16.0 |
| Spruce Grove | 465 | 598 | 3039 | 5.7 | 81.6 | 55.4 | 28.8 |
| Leduc | 2356 | 2856 | 4000 | 2.0 | 8.0 | 7.0 | 32.0 |
| Fort Saskatchewan | 2972 | 4152 | 5726 | 7.9 | 7.6 | 9.3 | 33.6 |
| Morinville | 935 | 995 | 1475 | 1.3 | 9.6 | 5.8 | 34.4 |
| Stony Plain | 1311 | 1397 | 1770 | 1.3 | 5.3 | 3.5 | 35.2 |
| Devon | 1418 | 1283 | 1468 | -1.9 | 2.9 | 0.4 | 38.4 |
| Redwater | 1135 | 1041 | 1287 | -1.7 | 4.7 | 1.3 | 59.2 |
| Wetaskiwin | 5300 | 6008 | 6267 | 2.7 | 0.9 | 1.8 | 70.4 |
| Tofield | 905 | 952 | 924 | 1.0 | -0.6 | 2.1 | 72.0 |
| Westlock | 1838 | 2685 | 3246 | 9.2 | 4.2 | 7.7 | 84.8 |
| Camrose | 6939 | 8362 | 8673 | 4.1 | 0.7 | 2.5 | 94.4 |
| Vegreville | 2908 | 3598 | 3691 | 4.7 | 0.5 | 2.7 | 100.8 |
| Ponoka | 3938 | 4421 | 4414 | 2.5 | 0.0 | 1.2 | 102.4 |
| Barrhead | 2286 | 2592 | 2803 | 3.7 | 1.6 | 2.3 | 120.0 |
| Lacombe | 3029 | 3035 | 3436 | 0.0 | 2.6 | 1.3 | 121.6 |
| Viking | 663 | 916 | 1036 | 7.6 | 2.6 | 5.6 | 137.6 |
| Mayerthorpe | 1043 | 1146 | 1178 | 2.0 | 0.6 | 1.3 | 139.2 |
| Rimbey | 1266 | 1502 | 1450 | 3.7 | -0.7 | 1.1 | 140.8 |
| Drayton Valley | 3854 | 3352 | 3900 | -2.6 | 3.3 | 0.3 | 142.4 |
| Athabasca | 1487 | 1551 | 1765 | 0.9 | 2.8 | 1.9 | 144.0 |

* Average annual percentage change in population
** Distance is measured from the center of the city
Source: 12

Figure 3-3

Study Area: Urban Centers of the Growth Space





Park (38.8%), St. Albert (19.1%), and Spruce Grove (55.1%). The next three closest urban centers all exhibited relatively high rates of growth - Leduc (7.0%), Fort Saskatchewan (9.3%), and Morinville (5.8%). Of the sixteen remaining urban centers there does not appear to be an identifiable ordering of growth rates according to distance from Edmonton. Two of these centers - Westlock (7.7%) and Mayerthorpe (5.6%) - displayed rates of growth similar to those found in the second group of centers closest to Edmonton. While some of the other fourteen centers maintained growth rates approximating the provincial average of 2.2%, most only underwent marginal increases.

The foregoing examination of general population growth trends in the growth space of Edmonton between 1961 and 1971 revealed that the highest growth rates occurred in those centers closest to Edmonton (Figure 3-4). In particular, the three closest centers experienced the highest growth rates while the next three closest centers had relatively high rates of growth. However, an examination of changes in these growth rates before and after 1966 appears to indicate that while the high growth rates of the immediately adjacent centers were varied, those of centers further from Edmonton - 25 to 50 kilometers - increased at an accelerated rate. Figures 3-5A and 3-5B graphically depict the growth rates of urban centers according to their distance from Edmonton for the years 1961 to 1966 and 1966 to 1971 respectively. Four categories of growth rates are distinguished by using the respective growth rate of Edmonton as a base rate for devising growth rate categories for each graph (Figures 3-5A and 3-5B).

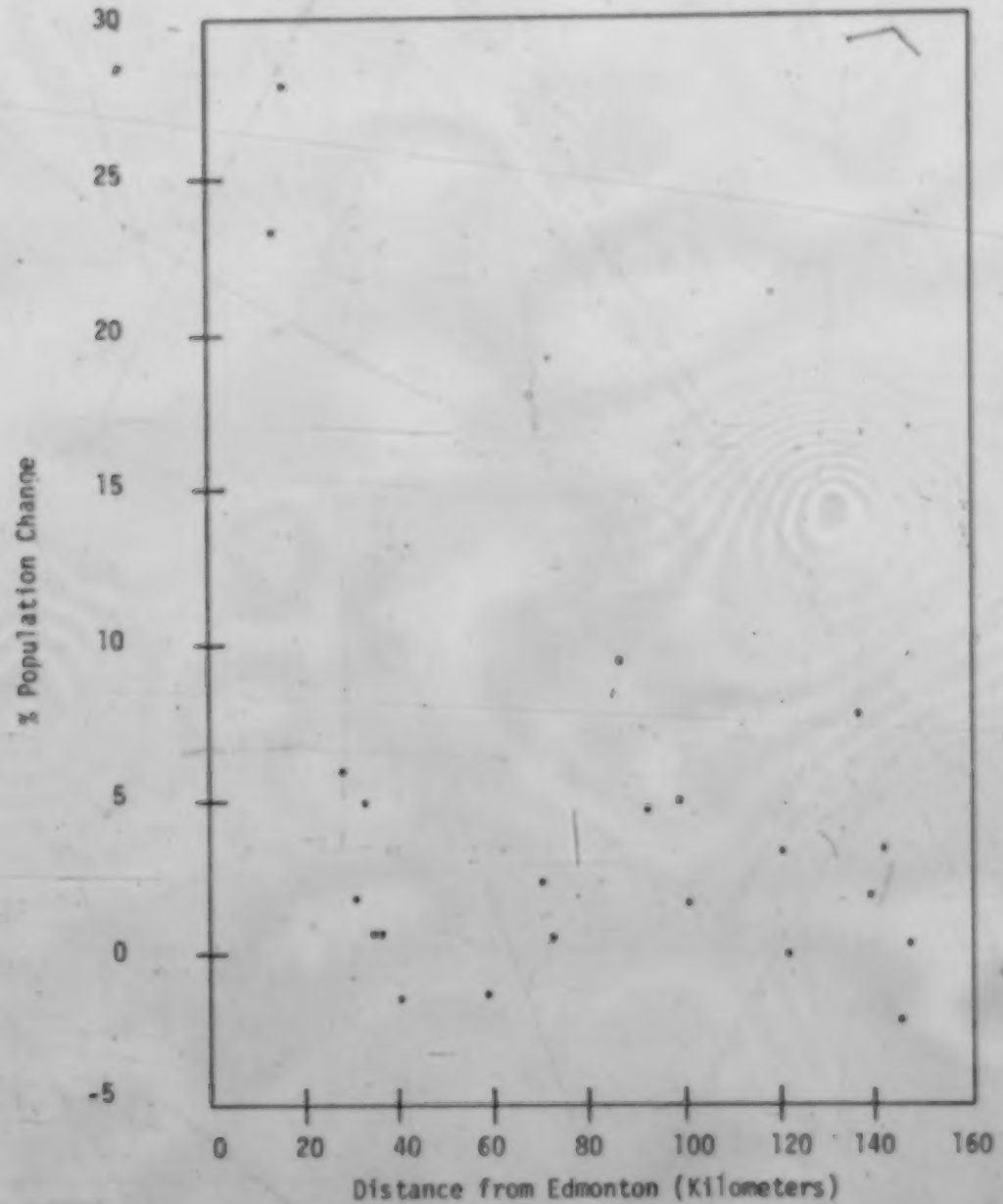
Figure 3-4

Distribution of Urban Centers by Growth Rate Category, 1961 - 1971

Source: Adapted from sources used in Table 3-3.

Figure 3-5A

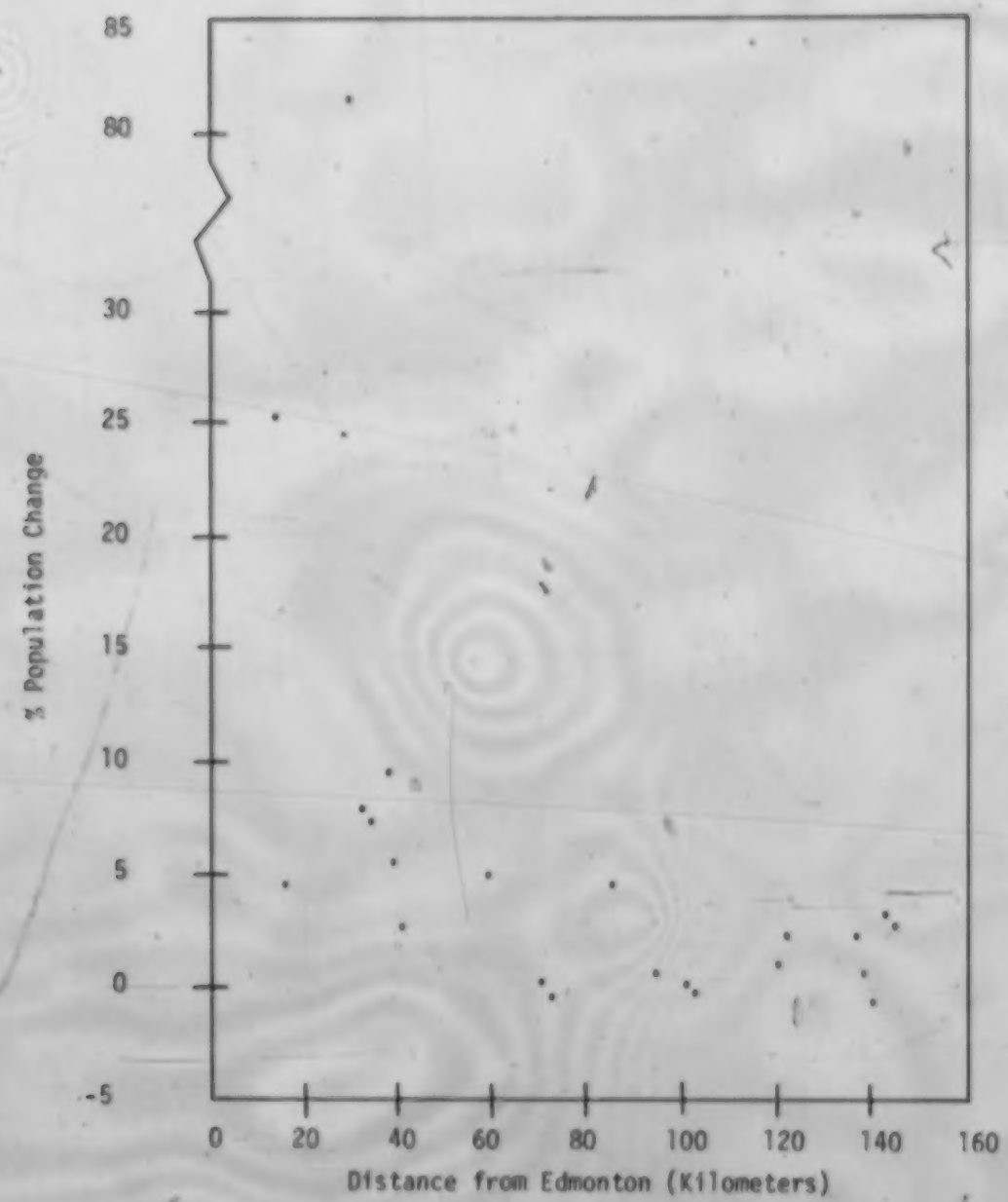
Population Growth of Urban Centers by Distance from Edmonton, 1961 - 1966




Source: Adapted from sources used in Table 3-3.

Figure 3-5B

Population Growth of Urban Centers by Distance from Edmonton 1966 - 1971




Source: Adapted from sources used in Table 3-3.

Visual inspection of Figure 3-5A reveals that the two closest centers of Sherwood Park and St. Albert were the only centers to have experienced growth rates greater than three times the 3.4% rate of growth for Edmonton. Three urban centers displayed growth rates of between two to three times that of Edmonton, while five had growth rates one to two times greater than Edmonton. The twelve remaining centers displayed growth rates of less than 3.4%. Figure 3-5B shows that the first and third closest centers displayed growth rates in excess of three times the 3.2% growth rate of Edmonton. The second category of centers in which growth rates were two to three times the base rate of 3.2% was comprised of the fourth, fifth and sixth closest centers, all lying within approximately thirty-two to thirty-five kilometers of Edmonton. The third category contained five centers, including the second and seventh closest. Of the twelve remaining centers in the fourth category, with rates of growth less than 3.2%, eleven were located more than seventy kilometers from Edmonton.

A comparison of the growth rates for the two periods shows that growth remained fairly stable, that is, each growth rate category had the same number of centers (Tables 3-4A and 3-4B). However, when distance was taken into account, a noticeable shift occurred between categories. Generally, the shift featured the accelerating growth of the eight urban centers within 50 kilometers of Edmonton, and a corresponding decline of growth of the nine centers beyond 100 kilometers. Growth rates in the middle group of five centers, between 50 to 100 kilometers from Edmonton, remained relatively stable. The accelerating growth of the first group

Table 3-4A

Growth Rate Category by Distance Group (1961-66)

| Growth Rate Category* | Distance Group: less than 50 klms | 50 to 100 klms | greater than 100 klms | Total |
|---|---|---|---|---|
| less than 3.4% | 4 | 3 | 5 | 12 |
| 3.4% to 6.79% | 1 | 1 | 3 | 5 |
| 6.8% to 10.19% | 1 | 1 | 1 | 3 |
| 12.2% and greater | 2 | 0 | 0 | 2 |
| Total | 8 | 5 | 9 | 22 |

* Growth rate categories are devised by using Edmonton's growth rate of 3.4% between 1961 and 1966 as a base rate.

Source: Adapted from sources used in Table 3-3.

Table 3-4B

Growth Rate Category by Distance Group (1966-71)

| Growth Rate Category* | Distance Group: less than 50 klms | 50 to 100 klms | greater than 100 klms | Total |
|---|---|---|---|---|
| less than 3.2% | 1 | 3 | 8 | 12 |
| 3.2% to 6.39% | 2 | 2 | 1 | 5 |
| 6.4% to 9.59% | 3 | 0 | 0 | 3 |
| 9.6% and greater | 2 | 0 | 0 | 2 |
| Total | 8 | 5 | 9 | 22 |

* Growth rate categories are devised by using Edmonton's growth rate of 3.2% between 1966 and 1971 as a base rate.

Source: Adapted from sources used in Table 3-3.

of eight urban centers is illustrated by the fact that between 1966 to 1971, seven of the ten centers with growth rates greater than the Edmonton base rate of 3.2% were located within less than 50 kilometers. In fact, six of these centers were the fastest growing centers throughout the entire growth space. In contrast, between 1961 and 1966, only four of the ten cities with growth rates above the base line of 3.4% were located less than 50 kilometers from Edmonton.

Whereas growth appears to be concentrating in the group of urban centers closest to Edmonton, there are indications that within these centers themselves this concentration is shifting away from Edmonton. While only one of the three urban centers closest to Edmonton showed a marked increase in the change of growth rate after 1966, four of the five next closest centers witnessed similar increased change. Although the overall growth rates of these four centers during the decade of 1961 to 1971 were not as high as the three centers closest to Edmonton, the majority of their growth was concentrated in the latter half of the decade. This rather fragmentary evidence suggests that the concentration of growth is shifting and that there is a trend toward the decentralization of population growth away from Edmonton.

## B. Development Patterns and Trends in the Growth Space of Edmonton

Relating population growth to distance raises a related question that concerns the degree to which other measures of development have undergone a similar process of spread, coincident with the apparent trend

of increasing decentralization of population growth. For, if in fact population growth trends are a reliable indicator of development trends, as argued at the outset of this chapter, then the latter should coincide to some extent with the former. To ascertain whether development trends exhibit similar spatial patterns as population trends, that is, whether development is related to distance from Edmonton, the performance of some key development measures is examined.

Development Measures[13] - A variety of indicators, termed development measures, are used in the present context, to provide a measure of economic development levels. The use of indicators, however, poses certain problems,[14] regardless of whether they are measuring economic development or other "areas of concern" such as standard of living, technological development or health. No one indicator provides an overall or comprehensive picture of what is being measured, nor do any two indicators provide an exact amount of what is being measured.

Standard of living, for example, could be measured by any one of a variety of economic indicators including income, gross national product or employment levels. Moreover, standard of living could also be measured by using such social indicators as the number of persons per dwelling unit or the hours of leisure time per week, or health indicators, for example, mortality rates, incidence of disease and so forth. Each indicator measures living standard in slightly different manner. Although this diversity enables the measurement of different aspects of living standard

or other areas of concern, there is no general agreement among researchers as to the *best* indicators.

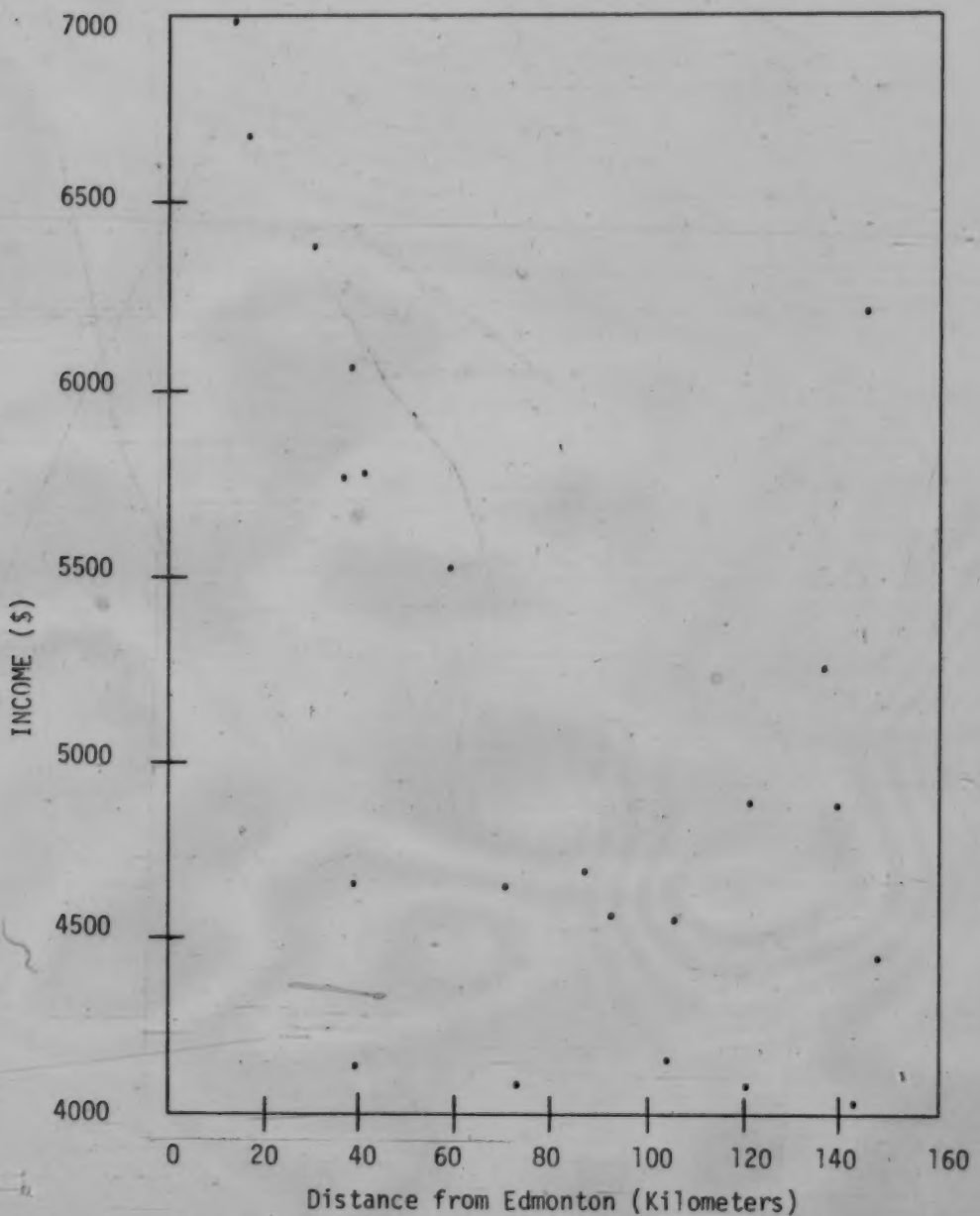
The development measures examined below are subjected to the same limitations outlined above. However, the intent is not to provide a comprehensive picture of economic development but, rather, to ascertain whether selected development measures exhibit spatial patterns similar to the population data.[15] The selection of particular development measure derives largely from the work of Logan (1970), Berry (1970a and 1973a) and Moseley (1973b) who used similar indicators to measure levels of economic development.

Income, despite its shortcomings, is an overall measure of development, because it is the primary determinant of purchasing power. Figure 3-6 depicts the average annual income of individuals in urban centers for 1971 by distance. Most of the centers closest to Edmonton exhibited considerably higher incomes than the other centers in the growth space. Indeed, six of the seven centers with the highest incomes lay within 50 kilometers of Edmonton. Four of the five closest centers had average incomes higher than Edmonton. Changes in income between 1961 and 1971 revealed a similar situation. Of the five urban centers that experienced gains in income greater than those recorded in Edmonton, four were located closest to Edmonton. Thus, incomes in 1971 and changes experienced during the previous decade suggest a trend similar to that revealed by the population data.

Greater purchasing power resulting from rising incomes was reflected in the average median value of single-family dwellings for 1971 and changes in the value of these housing units during the preceding decade.[16] The

Figure 3-6

Average Annual Income of Urban Centers by Distance from Edmonton, 1971




Source: Census of Canada, Family Income and Families by Number of Income Recipients, Series B, Table 3, Item 31, Alberta Burea of Statistics, Enumeration Area Printouts, July, 1975.

relation between average median dwelling value and distance, depicted in Figure 3-7, was not unlike that displayed in Figure 3-6. The six highest values were found in those centers closest to Edmonton; the two closest centers exhibited higher values than the metropolis itself. Changes in average median dwelling values between 1961 and 1971 showed that seven of the ten centers with the greatest absolute increase in dwelling value were located within 50 kilometers of Edmonton. Another important indicator of the state of prosperity is the number of new dwelling units. Again, the data reflect a situation that parallels the pattern identified in the foregoing examination of population growth, income and average median dwelling value (Figure 3-8) - that of the seven centers with the highest proportion of housing units built between 1961 and 1971, six were located within less than 50 kilometers of Edmonton.

Other measures of development that index levels of well-being include such amenities as auto ownership and the proportion of households owning dryers. Figure 3-9 shows that six of the seven centers with the highest average number of autos per household were located within 50 kilometers of Edmonton. Figure 3-10 displays a similar situation - five of the six urban centers in which the proportion of households with dryers was highest were also situated less than 50 kilometers from Edmonton.

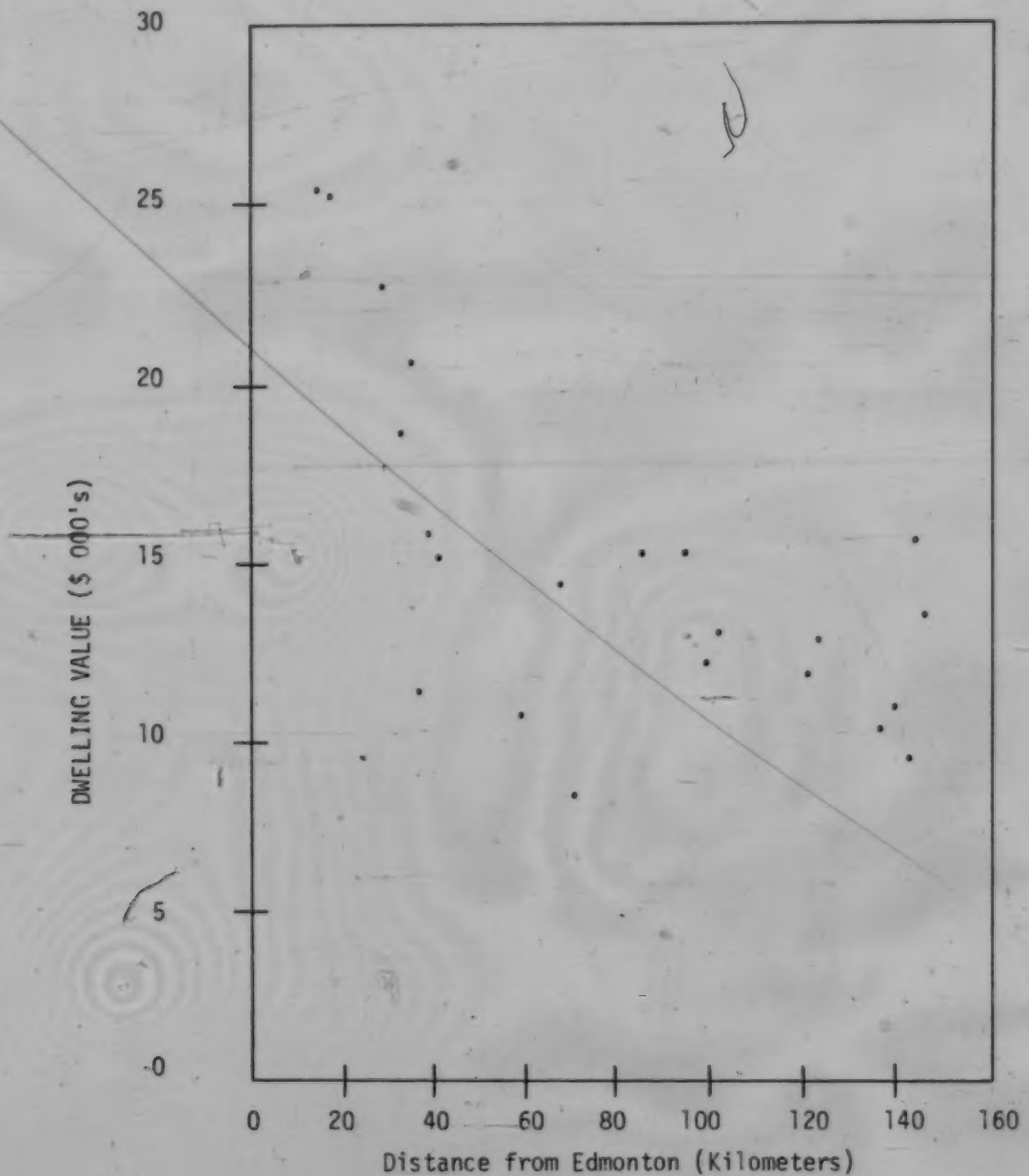
## C. Preliminary Indications of Edmonton's Impact on Growth and Development

### i. Commuting

Patterns of growth and development, and in particular the differences

Figure 3-7

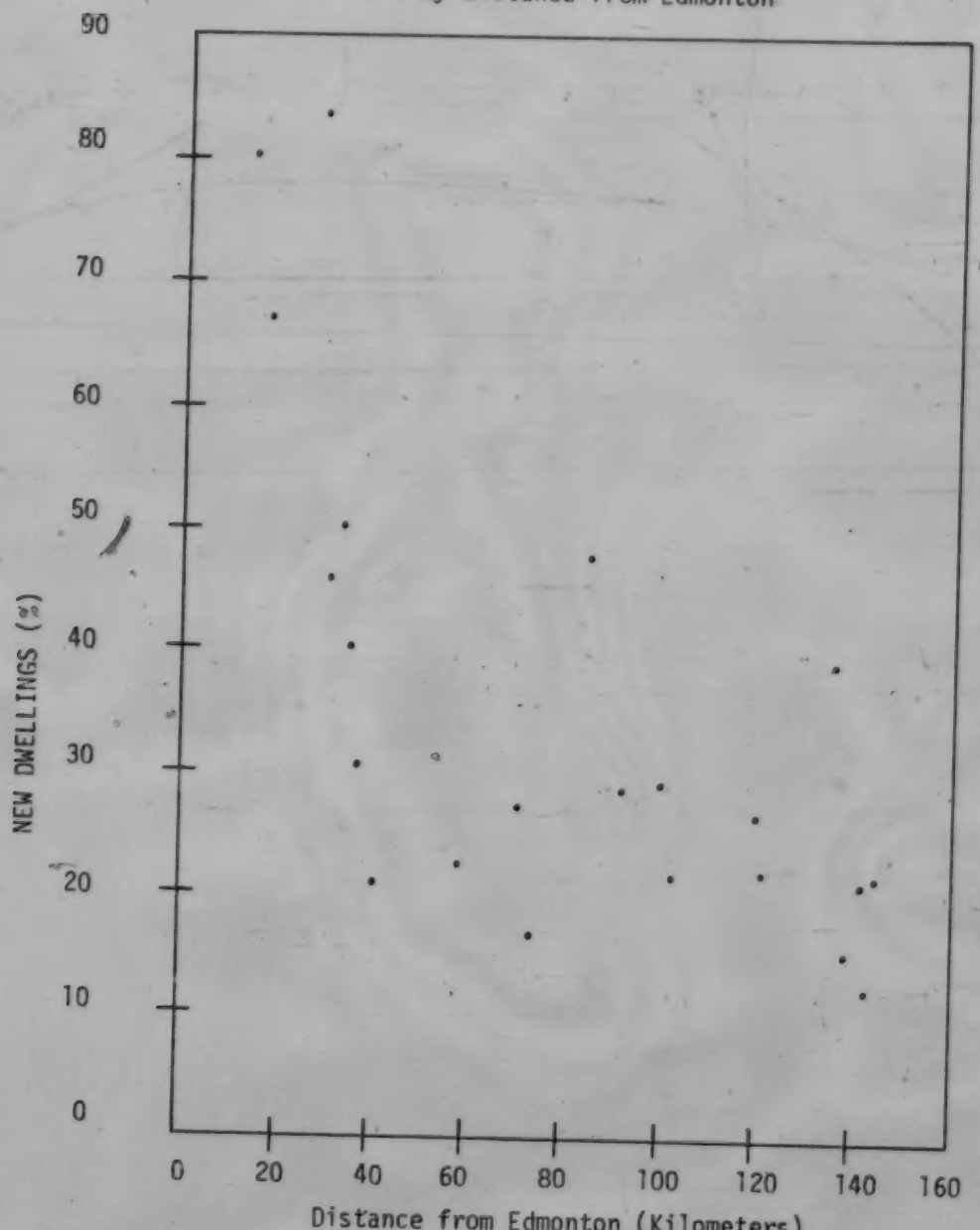
Average Median Dwelling Value of Urban Centers by Distance from Edmonton, 1971




Source: Census of Canada, Owner-Occupied Single House Non-Farm Dwellings by Value and Mortgage(s), Series A, Table 1, Items 68-72, Alberta Bureau of Statistics, Enumeration Printouts, December, 1973.

Figure 3-8

Proportion of Dwellings in Urban Centers Built Between 1961 and 1971 by Distance from Edmonton

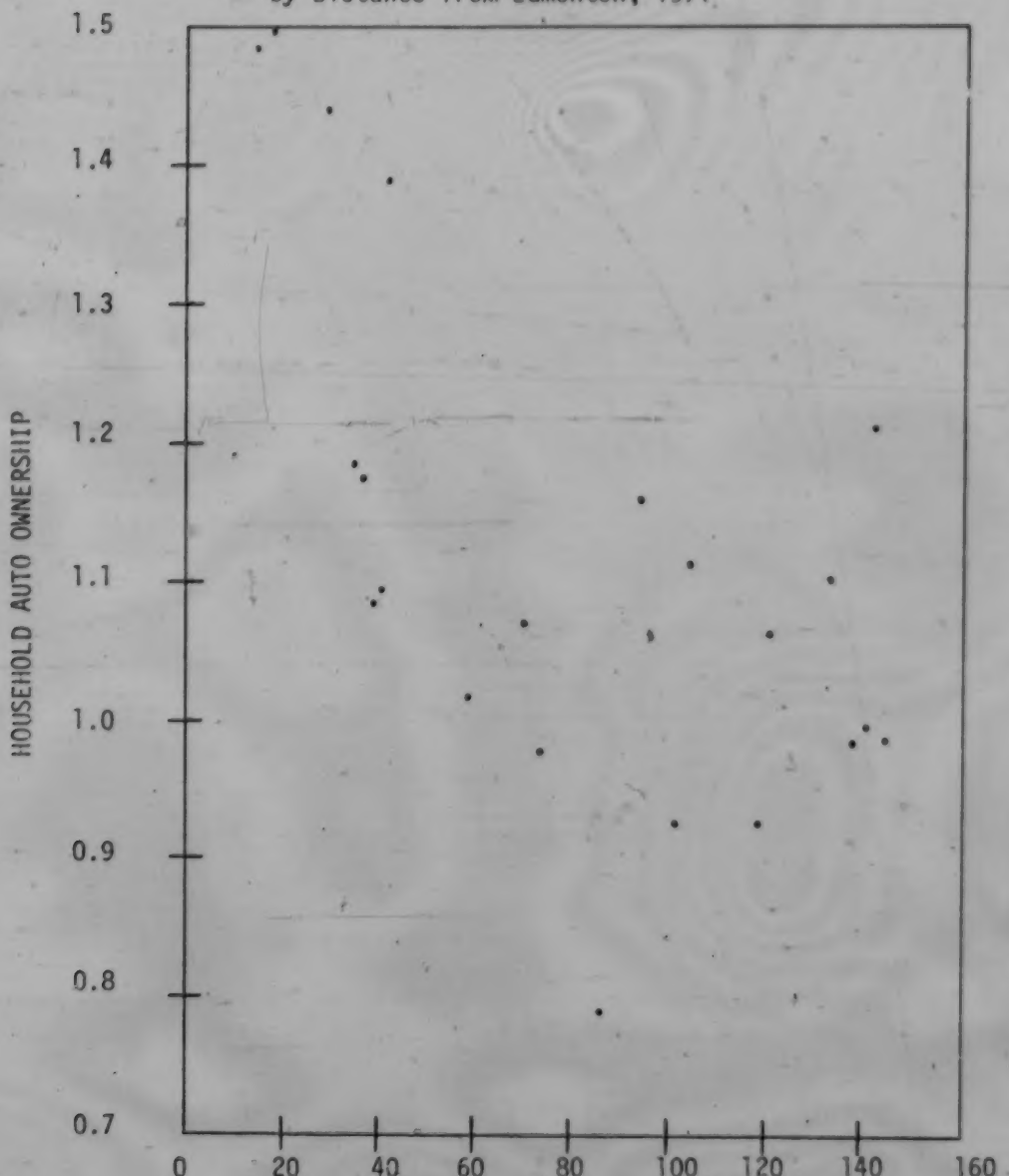



Source: Census of Canada, Tenant Occupied Non-Farm Dwellings, Series B, Table 2, Item 4, Alberta Bureau of Statistics, Enumeration Area Printouts, November, 1973.

Figure 3-9

Average Household Auto Ownership of Urban Centers

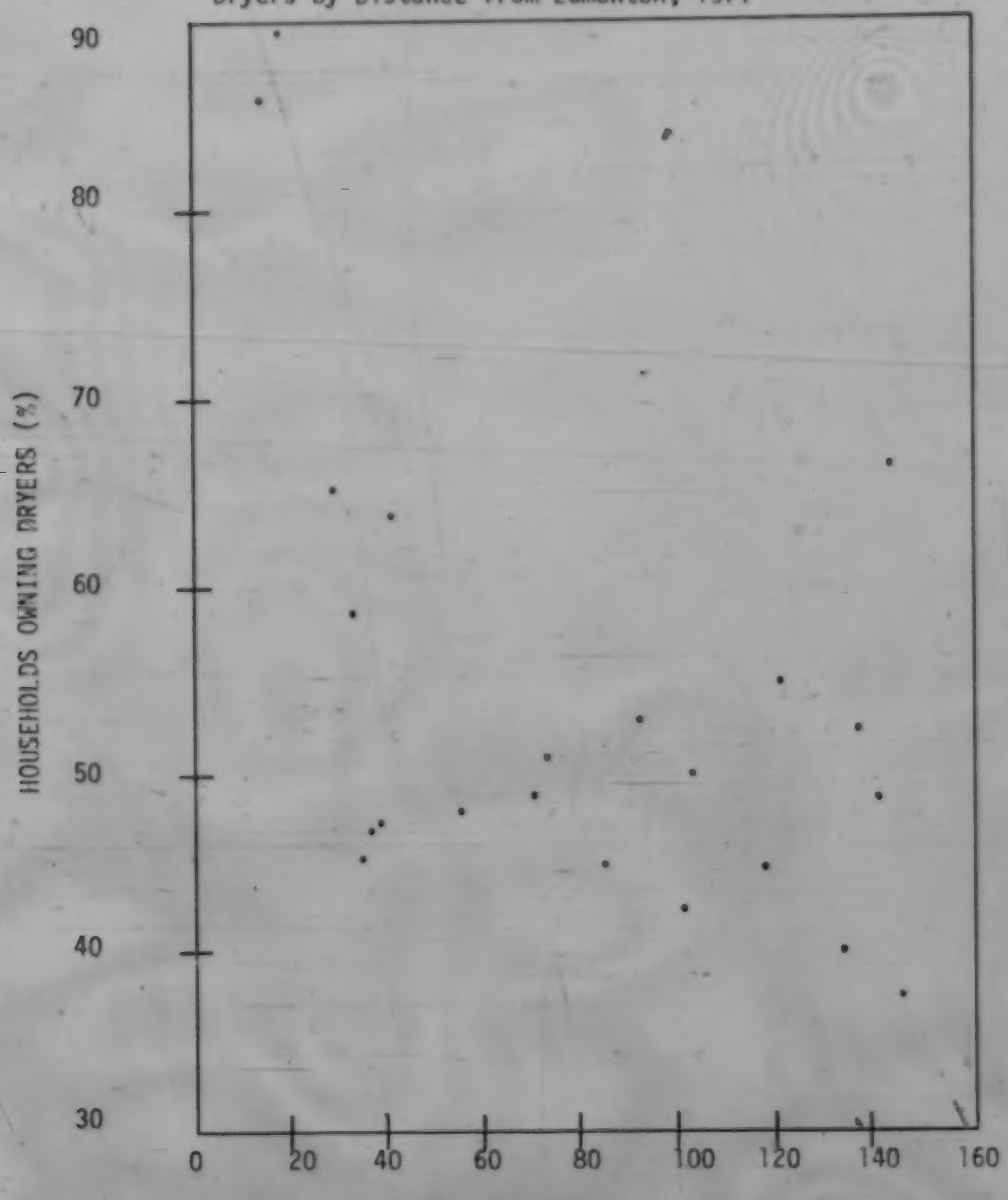
by Distance from Edmonton, 1971




Source: Census of Canada, Housing: Household Facilities, Series A, Table 23, Items 2-5, Alberta Bureau of Statistics, Enumeration Area Printouts, December, 1973.

Figure 3-10

Proportion of Households in Urban Centers Owning Dryers by Distance from Edmonton, 1971




Source: Census of Canada, Households: Household Facilities, Series A, Table 20, Item 5, Alberta Bureau of Statistics, Enumeration Area Printouts, December, 1973.

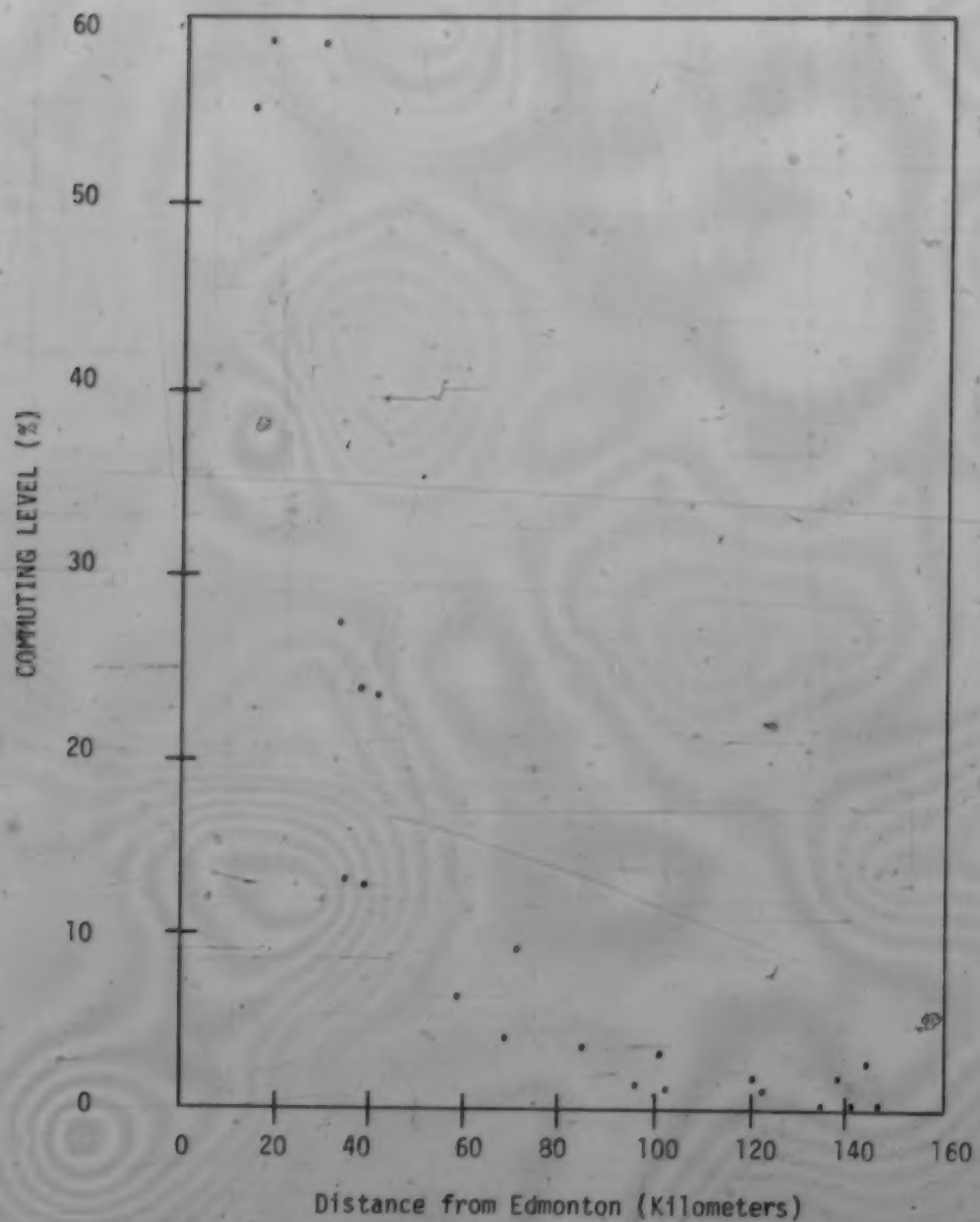
between the eight surrounding centers and fourteen outlying centers, are of relevance in the present context because these patterns appear to parallel commuting patterns of urban centers in the growth space (Figure 3-11). The high growth centers within 50 kilometers of Edmonton exhibited high levels of commuting to Edmonton, implying that Edmonton is exerting an impact on the growth and development of these centers via the labour market. In other words, higher growth rates and development levels of these surrounding urban centers derived, in part, from proximity to Edmonton and the concomitant opportunity to commute. These corresponding patterns of growth and commuting provide tentative support for the contention that participation in metropolitan labour markets is a key factor affecting the growth of surrounding urban centers. This supposition will be subjected to more rigorous analysis in Chapter Five.

ii. Retail Trade Activity.

The impact of Edmonton on patterns of growth and development is also evident in the level of trading activity of urban centers throughout the growth space. Berry (1960) argues that this phenomenon is one in which a metropolitan center, because of its wider range and diversity of goods and services usurps the trading activities of surrounding centers, and in particular, those activities related to higher order goods. The magnitude of this "functional usurption" is greater in those centers where a large proportion of the work force commutes to the metropolis; functional usurption tends to decline with distance from the metropolis as commuting levels and direct competition for trade with the metropolis declines. Using post office revenues as a surrogate for trade activity (Jones, 1965; Keys,

Figure 3-11

Commuting Levels by Distance from Edmonton, 1971




Source: [17]

1975), it can be shown that levels of trade activity decline with increasing proximity to Edmonton (Figure 3-12). Urban centers within 50 kilometers of Edmonton generally exhibited the lowest levels of per capita revenues suggesting that a considerable proportion of their trade activity is usurped by Edmonton.

iii Newspaper Circulation

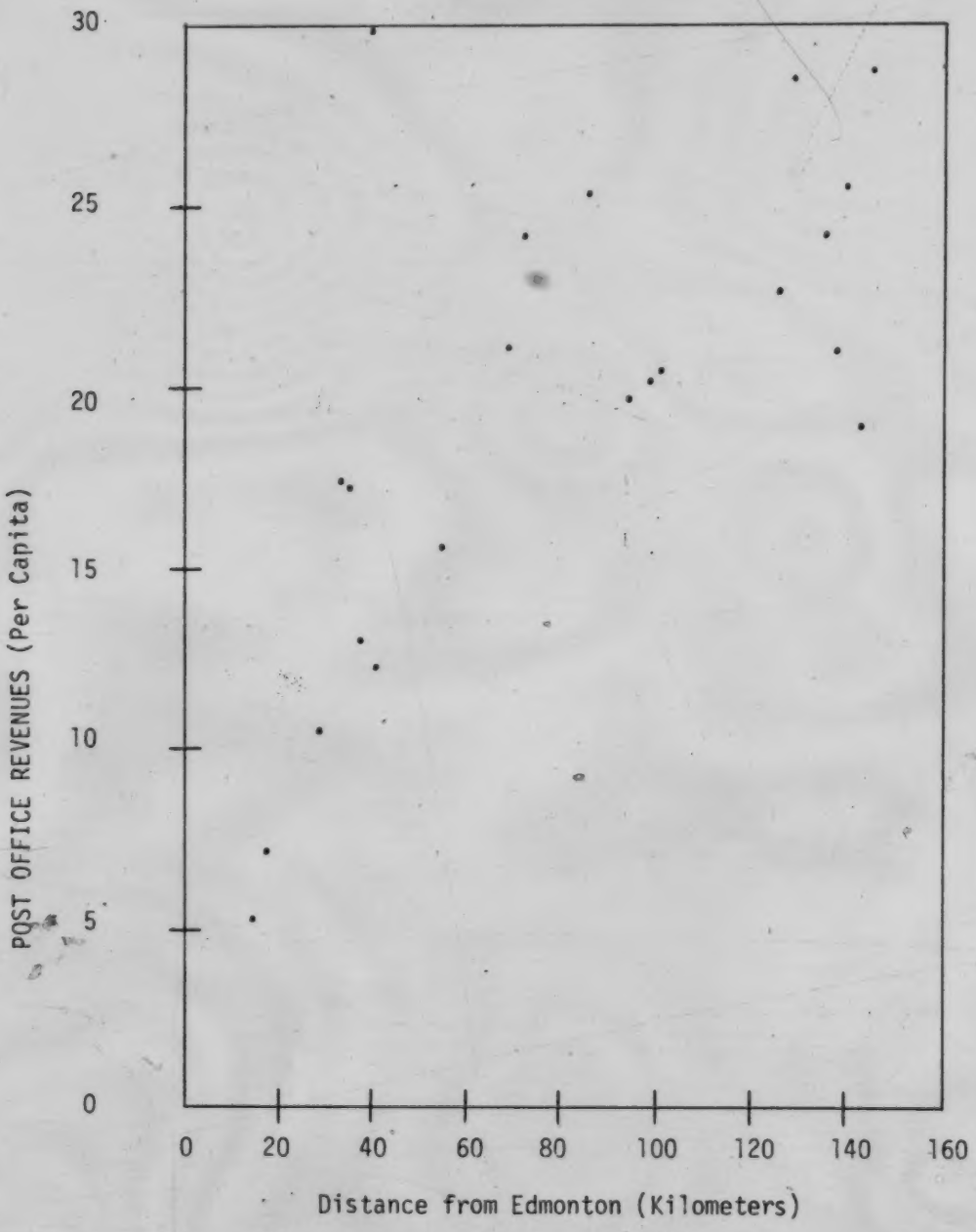
Edmonton's impact can also be shown by per capita circulation of the 'Edmonton Journal' (Figure 3-13). Berry was able to demonstrate that newspaper penetration was a measure of the impact of large urban centers, there was an inverse relation between newspaper circulation and distance from the metropolis (Berry and Niels, 1969; Berry, 1970a and 1973a). Urban centers within less than 50 kilometers of Edmonton generally exhibited higher levels of readership, suggesting that Edmonton is exerting an impact on urban centers of the commuting hinterland.

## IV. Discussion and Summary

The foregoing examination of recent population growth trends in the growth space of Edmonton indicated that significant changes in the pattern of growth and subsequent distribution of population have been occurring between 1961 and 1971. These changes were characterized by an apparent shift in the relative concentration of growth away from Edmonton to adjacent urban centers within a 50 kilometer radius. The emergence of these surrounding centers as focal points of growth has coincided with a general decline of growth among outlying urban centers that are located

Figure 3-12

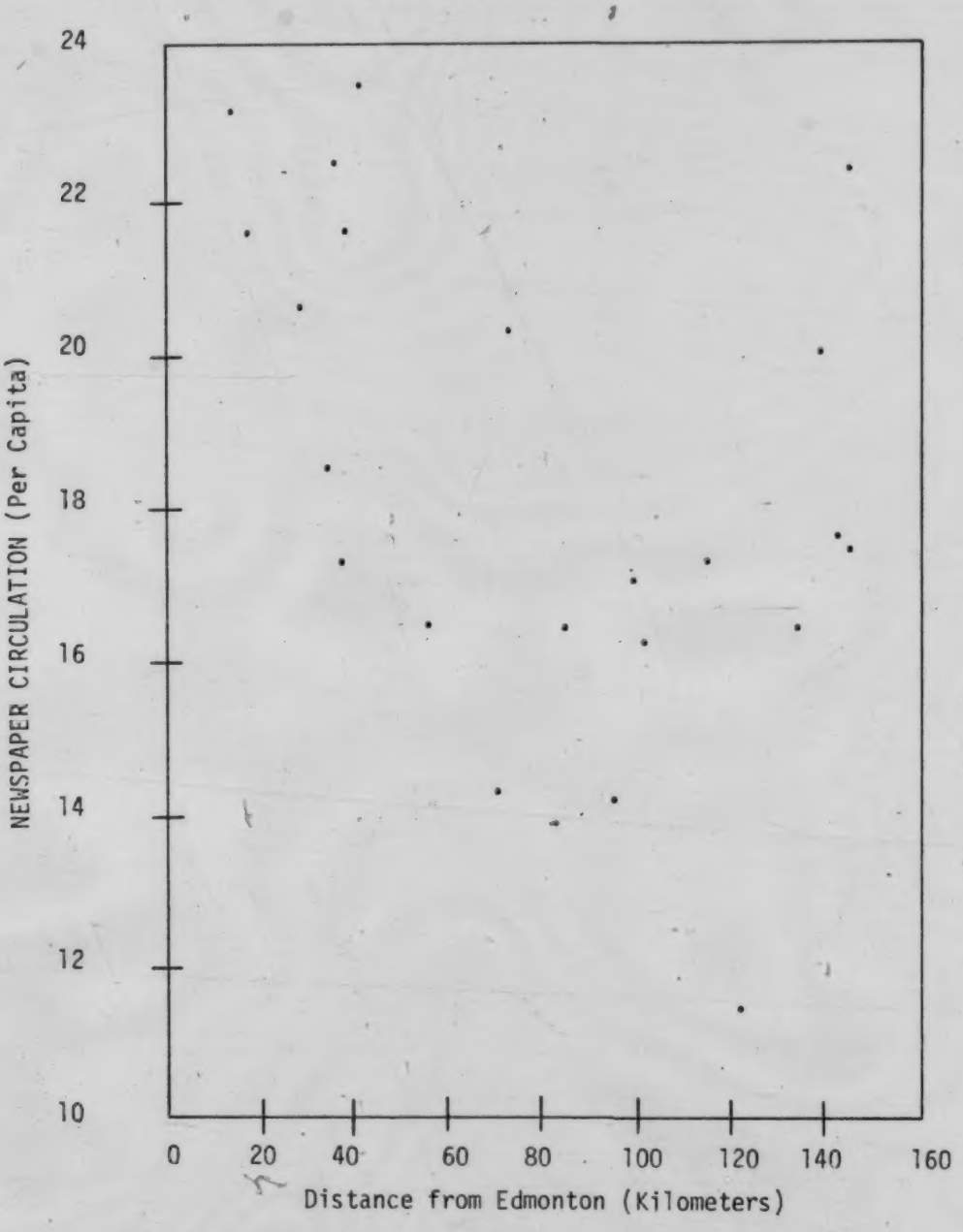
Per Capita Post Office Revenues by Distance from Edmonton, 1971




Source: Canada, Government of, Annual Report of the Postmaster General, Post Office Department of Canada, 1971.

Figure 3-13

Per Capita Newspaper Circulation by Distance from Edmonton, 1971




Source: Edmonton Journal, Circulation and Subscription Department, Edmonton, 1976.

beyond 50 kilometers from Edmonton. These overall population growth trends are summarized in Table 3-5. The first part of Table 3-5 displays the total population of Edmonton and the two groups of urban centers for the years 1961, 1966 and 1971. The major feature is the obvious concentration of population in Edmonton. Although this concentration is also apparent in the second part of Table 3-5, which shows the relative proportion of population for Edmonton and the two groups of urban centers, this concentration appears to be gradually declining. Whereas in 1961 Edmonton contained 85.9% of the total population, by 1971 its proportionate share of the total population had declined to 83.3%. A greater proportional decline among the outlying group of urban centers was also evident between 1961 and 1971. In contrast, the proportion of the population residing in the group of surrounding urban centers increased markedly from 4.4% to 8.3% during the same period. Even among these surrounding urban centers preliminary indications pointed toward a shift in the concentration of population growth away from those centers immediately adjacent to Edmonton to those centers that are located between 25 to 40 kilometers from Edmonton. This shift was evident in the accelerated growth rates of this latter group of centers.

Most of the surrounding urban centers had overall growth rates between 1961 and 1971 that were considerably greater than those of the outlying centers; moreover, these growth rate differences actually increased during the latter half of the decade. Although it is questionable as to whether the accelerating growth of the surrounding urban centers can be

Table 3-5

Total Population and Proportion of Population in Edmonton, Surrounding Urban Centers and Outlying Urban Centers, 1961, 1966, 1971

| | Total Population | | | Proportion of Population | | |
|---|---|---|---|---|---|---|
| | 1961 | 1966 | 1971 | 1961 | 1966 | 1971 |
| 1. Edmonton | 322238 | 376925 | 438152 | 85.9 | 84.7 | 83.3 |
| 2. Surrounding Centers | 16439 | 27256 | 43560 | 4.4 | 6.1 | 8.3 |
| 3. Outlying Centers | 36591 | 41161 | 44070 | 9.7 | 9.2 | 8.4 |
| Total | 375268 | 445342 | 525782 | 100.0 | 100.0 | 100.0 |

1. Edmonton central city population
2. Surrounding centers includes eight urban centers within 50 kilometers of Edmonton
3. Outlying centers includes twelve urban centers beyond 50 kilometers of Edmonton

Source: Adapted from sources used in Table 3-1 and Table 3-3

attributed in part to the concomitant decline of growth among outlying centers, there can be little doubt, however, that this growth derived largely from the proximity of these centers to Edmonton. The implication is that Edmonton is exerting an impact on levels of growth of urban centers in the growth space, that is, as distance from Edmonton increases the latter's impact declines and, consequently, levels of growth decline. The magnitude of this impact appears to be confined to urban centers within 50 kilometers of Edmonton. These urban centers all exhibited levels of commuting greater than 10%, suggesting that the magnitude of Edmonton's impact is essentially confined to the commuting hinterland. The magnitude of Edmonton's impact on trade activity and newspaper circulation supports the supposition that impact is essentially confined to the immediate commuting hinterland and provides further evidence to substantiate the contention that impact via the labour market is the single most important factor effecting impact.

The preceding examination of development trends in the growth space of Edmonton suggests that changes similar to those evidenced by the population data have taken place between 1961 and 1971. Development measures such as average annual income, average median dwelling value, housing construction, household automobile ownership, and proportion of households owning dryers were used to index levels of well-being of urban centers. Again, major differences were found to exist between surrounding centers located within a 50 kilometer radius of Edmonton, and outlying centers beyond 50 kilometers. Although no clear relation between distance and each of the various development measures was apparent in Figures 3-5 through

3-9, the surrounding urban centers, both individually and as a group displayed consistantly higher levels of well-being than the outlying centers. These differences are illustrated in Table 3-6, which facilitates comparison of the two groups of urban centers, as measured by the median values of the various development measures. The surrounding centers displayed significantly higher median values for all measures of development than the outlying centers. As well, all except one of these median values - average median dwelling value - was higher than corresponding values for Edmonton.

Clearly, then, levels of well-being of urban centers throughout the growth space of Edmonton exhibit a pattern that corresponds closely to the pattern of population growth. This pattern underscores the emergence of surrounding urban centers in close proximity to Edmonton as focal points of population growth and rising levels of well-being. Hence, based on the evidence derived from the examination of population data, commuting levels and development measures, the argument that population distribution and growth rates provide a good indication of development trends, presented at the outset of this chapter, can be reasonably accepted. This thesis will be taken up again in the latter part of the present study for the purpose of extrapolating post-1971 population patterns and trends to possible corresponding trends of development in the growth space of Edmonton.

The foregoing examination of population data and development measures of urban centers throughout the growth space has touched upon a number of issues that require further and more rigorous investigation. Of particular

Table 3-6

Median Value of Development Measures in Edmonton, Surrounding Urban Centers and Outlying Urban Centers, 1971

| Development Measures | Edmonton | Surrounding Centers | Outlying Centers |
|---|---|---|---|
| Average Annual Income ($) | 5777 | 5972 | 4725 |
| Average Median Dwelling Value ($) | 23573 | 19734 | 12317 |
| Dwellings Built Since 1961 (%) | 40.5 | 43.3 | 24.3 |
| Proportion of Households Owning Dryers (%) | 52.2 | 60.7 | 49.6 |
| Number of Autos per Household | 1.12 | 1.29 | 1.00 |

Source: Adapted from sources used in Figures 3-5 to 3-9

relevance is the magnitude of Edmonton's impact via commuting on patterns of growth rates and development levels of urban centers, and the spatial form of these patterns. The following chapters set out to investigate, in detail, these and other related questions within the context of the objectives of the present study.

## Chapter Three Footnotes

1. Census of Canada, Population: Urban and Rural Distributions, Catalogue 92-709, Vol. 1, Part 1, (Bulletin 1.1-9), Feb., 1973, pp. 2-10. Census of Canada, Population: Rural and Urban Distributions, Catalogue 92-536, Vol. 1, Part 1, Series 1.1, Bulletin 1.1-7, 8/2/63, p. 14-12.

2. Ibid.

3. Ibid.

4. Referred to as the largest city (1971) or city proper (1961, 1966) the central city is defined as the "most populated urban municipality around which a Census Metropolitan Area or Census Agglomeration is delineated. It is automatically part of the urban core. Usually, its name is used as the name of the Census Metropolitan Area or Census Agglomeration". Census of Canada, Dictionary of the 1971 Census Terms, Catalogue 12-540, December, 1972, p. 50.

5. Population growth rates are expressed according to the average annual growth rate unless otherwise specified.

6. Census of Canada, Population, Census Subdivisions (Historical), Catalogue 92-702, Vol. 1, Part 1, (Bulletin 1.1-2), July, 1973, p. 1-1.

7. A Census Metropolitan Area (C.M.A.) is defined at the "main labour market area of a continuous built-up area having 100,000 or more population. There are 22 C.M.A.'s in Canada, each having an urbanized core, largest city, remainder and fringe, urban and rural parts". Census of Canada, Dictionary of the 1971 Census Terms, Catalogue 12-540, December, 1972, p. 47.

8. The fringe is defined as being comprised of "all of the Census Metropolitan Area . . . except the largest city". Census of Canada, Dictionary of the 1971 Census Terms, Catalogue 12-540, December, 1972, p. 50.

9. The actual Edmonton central city population in 1961 was 281,027. The figure of 322,238 is used by the Census of Canada to refer to the 1961 central city population that resided in the 1971 central city boundaries. This latter figure is used to remove the effects of large population increases resulting from annexations of Beverly Town and Jasper Place Town. For more detailed information on annexations to Edmonton, see: Census of Canada, Population: Census Subdivision (Historical), Catalogue 92-702, Vol. 1, Part 1, (Bulletin 1.1-1), July, 1973, p. 249, Division II, Footnote 3.

10. "The urban population includes all persons living in: (1) incorporated cities, towns, and villages with a population of 1,000 and over; (2) unincorporated places of 1,000 or over, having a population density of at least 1,000 per square mile; (3) the urbanized fringe of (1) and (2)". Census of Canada, Dictionary of the 1971 Census Terms, Catalogue 12-540, December, 1972, p. 56.

    "A city with a population of 1,000 and over is considered as urban for census purposes". Census of Canada, Dictionary of the 1971 Census Terms, Catalogue 12-540, December, 1972, p. 56.

11. With the exception of Sherwood Park, all of these centers are self-administered, self-contained urban units. Each has their own civic or municipal government or authority. Sherwood Park is an unincorporated hamlet in the County of Strathcona, whose non-farm population meets the urban definition of the Census of Canada.

12. (A) For population and percentage population change of all urban centers except Sherwood Park: Census of Canada, Population: Census Subdivisions (Historical), Catalogue 92-702, Vol. 1, Part 1, (Bulletin 1.1-2), July, 1973, pp. 2-106 - 2-109.

(B) For population and percentage population change of Sherwood Park (1966, 1971): Census of Canada, Population: Unincorporated Places, Special Bulletin, Catalogue 92-771 (SP-1), March, 1973, p. 94.

(C) For population and percentage population change of Sherwood Park (1961): Census of Canada, Population: Unincorporated Settlements.

(D) For distance of urban centers from Edmonton: Government of Alberta, Mileage Chart, Primary Highways, Highways and Transport Construction Branch, February, 1975.

13. Development measures refer to economic development unless otherwise specified.

14. For a detailed discussion see Haggett (1975).

15. The procedure for combining these measures into a multiple index(es) will be outlined in the following chapter.

16. Other factors such as the availability and quality of servicable land, demand for housing, and housing location relative to the central business district, also affect housing prices.

17. Source: For all urban centers except Sherwood Park - Census of Canada, Employed Labour Force by Residence and Place of Work, Alberta Bureau of Statistics, Place-of-Work, Place-of-Residence Tapes, June, 1976.

For Sherwood Park - Alberta Department of Transportation, Sherwood Park Census and Work Travel Questionnaire, November, 1974.

# CHAPTER FOUR

# THE RESEARCH METHODOLOGY

## I. Introduction

An exposition of the methodology used to empirically test the series of linked hypotheses put forward in the first chapter comprises the major focus of the present chapter. The first section describes the methods whereby the *index of development* is derived. Particular attention is aimed at the statistical techniques used to construct this *index of development* and the variables that comprise the data set from which the *index of development* is constructed. The second section describes the application of a statistical model used to test hypothesized relationships outlined in Chapter One. Although emphasis is placed on the statistical techniques of the model that are used to test the hypotheses, the limitations of the model are also examined in detail.

## II. *Index of Development*

### A. Factor Analysis

In constructing the *index of development* the major objective is to seek out patterns of regularities in the variables that comprise the data set. In doing so, it is then possible to produce an index that best describes or summarizes the nature of those patterns or regularities found

to exist among the various measures of development. The factor analytic procedure is best suited for such a purpose because it can be utilized to ascertain the degree to which the variables of a data set indicate similar patterns. Furthermore, if such patterns are weak or non-existant, the procedure can be used to develop a new set of hypothetical variables, fewer in number, but linearly associated with, and accounting for the variation in the original variables.

i. Uses of Factor Analysis

In addition to the useful applications of factor analysis mentioned above, the procedure offers a number of advantages in the present research. First, it simplifies the management, analysis, and understanding of a large set of data by reducing them to their common factor patterns. These factors concentrate and index the array of information in the original variables while preserving the majority of information contained therein. Second, factor analysis can be used as a tool for developing an empirical typology (Selvin and Hagstrom, 1963; Russett, 1966, and 1967) by grouping inter-related variables into descriptive categories termed "factors". These *factors* can then be measured or scaled on the basis of empirical relationships among the variables, to test for the empirical existence of intercorrelations among variables. Third, factor analysis may be used to test assumptions or hypotheses, derived from theory, about the nature of the patterns inherent in the data set. Such a deductive approach involves hypothesizing the existence of particular patterns, and then factor-analyzing the data to determine whether such patterns emerge (Cattell, 1952, pp. 13-14).

A fourth use of factor analysis in the present context is its ability to generate a hypothetical set of data called *factor scores* that can be incorporated in other statistical techniques. In this regard, the factor analytic procedure can be helpful in transforming data to meet the assumptions of other analytical techniques. The application of multiple regression, for example, requires that the independent or explanatory variables are statistically uncorrelated (Ezekiel and Fox, 1959, pp. 283-284). If the explanatory variables are related, in violation of this assumption,[1] factor analysis can be employed to reduce these variables to a smaller set of uncorrelated variables represented by *factor scores*. These *scores* can then be used in a regression analysis with a minimum amount of information loss in the original data. Similarly, a large number of dependent variables can also be reduced in this manner.

ii Principal Components Analysis

If the uses of factor analysis are many and varied, then the same can be said for the application of the factor model. In all, there are five factor models.[2] Principal components analysis is applied in the present research to construct an *index of development*, for, if the existence of "syndromes of interrelated phenomena" (Berry, 1965, p. 23) are to be confirmed, it is necessary to examine all the variation in the data set. Principal components analysis is used in the present analysis because, unlike the widely used common factor model, it enables patterning of both the common and unique variation in a set of variables.

Although it is beyond the scope of this study to detail the mathematics

underlying this widely accepted tool of spatial analysis (King, 1969), an exposition of the salient aspects of this technique will be helpful for purposes of analysis and interpretation of results. In essence, principal components analysis seeks *clusters* of correlated variables that index the pattern of relationships in the data, each *cluster* being a pattern. Each variable in a cluster is geometrically represented by a vector point. Axes or *components* are then projected through the vector points that comprise the cluster in such a way so as to fall through the clusters' center of gravity. Each *component* or *factor* is independent of all others because these projected axes are by design *orthogonal*, that is, each axis is projected at a 90 degree angle to all other axes, thereby ensuring that each factor is uncorrelated. The relation of each variable in the cluster to the projected factor axis is referred to as the variable *loading*. These variable *loadings* are contained in the *loadings matrix* which can be interpreted like a correlation matrix in that the *loadings* represent correlations between the variables and factors, indicating the contribution of each original variable to each factor. Finally, a *scores matrix*, indicating the degree to which each factor features in each observation - urban center - is produced. The *scores* are derived by combining the original standardized data[3] with the loadings for the respective component. In essence, the loadings act as weights to modify the standardized data. These *scores* represent the relative strength to which a pattern depicted by a factor or component is evidenced at an urban center. High positive scores or negative scores of greater than plus or minus one, reflect a strong and weak presence, respectively.

iii Procedural Problems

The foregoing cursory review of principal components analysis evidences the diversity of uses and complicated techniques involved in applying the model. A further consideration involves procedures employed in carrying out those techniques. Two procedural questions are considered: the *cut-off* point in the selection of components; and factor loadings used to identify or label components.

In principal components analysis each pattern represents the *best* linear combination of the variables - *best* in that the particular combination of variables accounts for more of the variance in the data set as a whole than any other linear combination. The first factor pattern, or principal component, may be viewed as the single best summary of the pattern of linear relationship inherent in the data. The second component is considered the second best linear combination of variables, accounting for the largest possible proportion of the variance not subsumed by the first or principal component. Thus, the second component, orthogonal to the first, is defined as the linear combination of variables that accounts for the most residual variance, after the effect of the principal component has been removed from the data. Subsequent components are defined in the same manner until all the variation in the data has been accounted.

In theory, the number of components extracted equals the number of original variables, thereby ensuring that all the variance in the data set is accounted. Extracting an equal number of components, however, violates parsimony because it does not lead to a reduction of the data set. The

question therefore becomes one of determining the number of components to be extracted for further investigation. An extensive survey of the various methods for determining the number of components to be extracted for further examination or analysis is given by Rummel (1970, pp. 349-367), wherein he describes criteria based on inference, mathematics, and *rules of thumb*. From the plethora of different types of tests, two are employed in the present analysis. One involves the extraction of components with *eigenvalues*[4] greater than one (Kaiser, 1960), a method used by Logan (1970) and Moseley (1973b). Though this *rule of thumb* has a sound mathematical base, it must be employed with caution, particularly if there are a number of components with eigenvalues close to one. Thus, a second criteria is used to exclude all components that contribute less than five percent to the overall explanation of the model (King, 1969) on the basis that such components are likely to contain a large random-error variance (Yeates, 1974). Only those components that satisfy both criteria outlined above are extracted for further investigation.

## B. Operational Definitions and the Data Base

### i Time Period of Study

Several questions require careful consideration in constructing the *index of development*, particularly for purposes of statistical analysis; treatment of these questions is likely to have a considerable effect on the interpretation of the results. The first question involves the time period of the study, and because data availability necessitates an historical examination, the information is obtained from secondary sources primarily

for the year of 1971.[5] The year of 1971 is selected because most of the required information is to be found in the Census of Canada. For purposes of identifying trends or changes in the data, corresponding information for the year of 1961 is also used whenever available and relevant.

ii Selection of Variables

A second consideration involves the selection of variables that are to comprise the data set from which the *index of development* is derived. In constructing the *index of development* the intention is to portray as many aspects as possible of the state of development or prosperity, while at the same time, avoiding inclusion of variables that are simply variants of one another. An effort is made to ensure that each selected variable reflects the effects rather than the causes of development. Whenever possible or practical, a dynamic element of the variable under consideration is incorporated into the data set, by using a measure of change in that variable between 1961 and 1971. Finally, only those variables for which information is available for the study date of 1971 are used.

The variables that comprise the data set used to construct the *index of development* are listed in Table 4-1, along with their appropriate abbreviations that are used throughout the text, and the dates in which information for these variables was obtained. Most of these variables are similar to those used by other researchers to measure levels of economic development (Logan, 1970; Berry, 1970a and 1973a; Moseley, 1973b and 1974). Other variables were also considered. Educational levels are not included

TABLE 4-1

Variables Used to Construct the *Index of Development*

| Variable | Date | Abbreviation |
|---|---|---|
| 1. Average Income of Wage Earners | 1971 | INC71 |
| 2. Average Median Dwelling Value | 1971 | AMDV71 |
| 3. Tenure (ratio of rented:owned) | 1971 | TENURE71 |
| 4. Average Number of Autos per Household | 1971 | AUTO71 |
| 5. Proportion of Households Owning Dryers | 1971 | DRYER71 |
| 6. Labour Force Participation Rate | 1971 | LFPR71 |
| 7. Proportion of School-Age Population | 1971 | LT15YR71 |
| 8. Per Capita Newspaper Circulation | 1971 | PCCIRC71 |
| 9. Per Capita Post Office Revenues | 1971 | PCPO71 |
| 10. Average Income Change | 1961-71 | INC6171 |
| 11. Average Median Dwelling Value Change | 1961-71 | AMDV6171 |
| 12. Household Auto Ownership Change | 1961-71 | AUTO6171 |
| 13. Labour Force Participation Rate Change | 1961-71 | LFPR6171 |
| 14. Post Office Revenue Change | 1961-71 | PCPO6171 |
| 15. Population Change (growth rate) | 1961-71 | POP6171 |
| 16. Proportion of Dwellings Built After 1961 | 1961-71 | DWELLNEW |

because they were found to be a variant of income levels. Other variables such as the proportion of households with freezers, bath or shower, and running water were not investigated because they were not considered to measure levels of urban well-being but, rather, were more significant in rural areas. Data for the number of telephones per household were not accessible, while information about the volume of retail and service trade was found to be inconsistant and unavailable for urban centers with a population of less than 2,000.

The first group of five variables in Table 4-1 are self-explanatory measures of the standard of living, as indexed by average annual individual income, housing characteristics of value and tenure, and domestic conveniences or amenities. The second group, variables six and seven, is comprised of two variables that portray vibrant demographic characteristics of both the young and the working population.

Variables eight and nine are intended to reflect or gauge opposite effects of developmental spread. On the one hand, the positive relation between newspaper penetration and distance from a metropolis[6] (Berry, 1969, 1970b, 1973a) suggests that levels of development should correspond with levels of circulation. Indeed, Berry (L969, 1970b, 1973a) was able to show that the percent of newspaper market penetration measured the magnitude of spread effects of development of metropolitan centers on surrounding areas. On the other hand, higher levels of development should be reflected by lower levels of post office revenues per capita because of some usurption of these fundtions by other metropolitan centers (Berry, 1960. VonBoventer, 1970).

Post office revenues, rather than retail sales, are used in the present study because they have been shown to be a more stable and reliable surrogate for gauging the volume of trade (Keys, 1975), and information is more readily available. Moreover, both Jones (1965) and Keys (1975) found a high correlation between post office revenues and retail sales for places with a population of greater than 1,000 in British Columbia and Alberta respectively. Since post office revenues are used primarily to index the magnitude of developmental spread, rather than measure levels of retail activity, they are considered to be a suitable surrogate measure of trade volumes.

The remaining variables, ten through sixteen, index changes that have taken place during the previous decade of 1961 to 1971; these variables show the magnitude of change over time. The variables relating to income, dwelling value, and auto ownership reflect changes in the levels of well-being. Changes in the rate of labour force participation are intended to portray possible shifts in the population profile and levels of employment activity, while changes associated with post office revenues are used to ascertain possible trends of trade centralization. Finally, two additional variables are examined - newly constructed dwelling units and population growth. These two variables are good overall measures of change because areas of rapid population growth and subsequent housing expansion usually take place in, or give rise to, areas with high levels of development. Consequently, areas with high or accelerating growth rates often exhibit high or rising levels of development, while at the same time, the converse holds true. Hence the importance of these two variables in identifying initial trends of growth or decline is critical, and their inclusion in constructing the *index of development* is essential.

iii Measurement of Variables

A third consideration deals with an appropriate type of measurement for each of the selected variables. The nature of the variables is such that different variable units of measurement are necessary. There is no one type of unit measurement for all variables; each is measured in a manner consistent with its particular composition.

The average income of wage earners and average median dwelling values are measured in 1971 constant dollars. Changes in these variables between 1961 and 1971 are also examined. The interpretation of these changes is made easier by using a base rate measured in 1971 constant dollars, thereby removing the effects of increases in the cost of living indicated in the consumer price index. All 1961 data are therefore expressed in terms of 1971 constant dollar values by multiplying these data by a figure of 1.33 to account for a rise in the cost of living of 33% during the previous decade.[7] Changes in these two variables are measured in absolute dollars rather than percentage figures. Although percentage increases are often utilized because they facilitate conclusions concerning income convergence and divergence, such implications may be misleading. This situation arises where initially low income levels display greater percentage increases than higher income levels, when in fact differences in absolute change may be negligible. For example, a center with a low level of income may exhibit extremely large percentage increases, while a high income center may only show moderate percentage increases, whereas both centers may have experienced similar gains in absolute terms. The situation is only of relative uniformity in absolute dollar increases, leading to high percentage increases in centers of low income and smaller percentage increases

in centers of higher income, a situation similar to that found by Perloff, et.al., in their analysis of per capita income change between states from 1927 to 1955 (Perloff, et.al., 1960, p. 505).

Tenure refers to whether a private occupied dwelling is owned or rented by a member of the household.[8] The tenure ratio measures the ratio of owner-occupied dwellings to those that are rented. The ratio is made easier to interpret by using a base of one for rented dwellings; the ratio can therefore be read as the number of owner-occupied dwellings for every one dwelling that is rented. The tenure ratio itself provides an indication as to the stability and wealth of the population. Higher rates of household ownership imply greater stability and usually indicate the ability to purchase, thereby implying some degree of wealth.

Auto ownership is a surrogate for many different types of measures, for example, mobility and consumption. It is measured by calculating the average number of automobiles per household. The proportion of households that own dryers is a variable that also reflects consumption. It is measured proportionately because, unlike auto ownership, it is assumed that a household does not normally own more than one dryer.

The two variables that index *activity levels* of the population are both measured in percentage terms. The rate of labour force participation is determined by calculating the percentage of the eligible labour force that is gainfully employed.[9] A problem arises, however, because many of those that are eligible for work are attending secondary or post-secondary institutions, and inclusion of this segment of the population tends to distort the rate of labour force participation. Precluding the segment of the population attending

such institutions was not possible given the aggregated form of the original data. Nonetheless, the distortion is not so great as to consider deleting this variable from the analysis, for it does provide some insight into the degree of vitality of the urban population. The second measure of *activity levels* is the proportion of the population that is less than fifteen years of age - the school-age population. Large proportions of this youthful group indicate that the population is comprised mainly of family units, representing a particular phase in the family life cycle (Shevky and Bell, 1955), that implies a stable and often growing population with relatively high levels of income and favourable housing.

Both newspaper circulation and post office revenues are measured on a per capita basis to facilitate the interpretation of variations over distance while removing or holding constant the effects of population. Per capita newspaper penetration or readership of the 'Edmonton Journal' reflects the degree to which surrounding centers either depend on or prefer to read the Edmonton paper, and so are exposed to news and advertising in Edmonton. Per capita post office revenues, as a surrogate for trading volume, indicate the trading strength of an urban center. Low per capita revenues imply usurption of trade activities (Keys, 1975), although this may also reflect low levels of income. Of course, it is not possible to determine either the degree of ursurption of specific trade activities or to where this lost trade is going; only general statements as to the overall loss of trade can be made. In areas surrounding a metropolis, functional usurption is often characterized by a trend toward the centralization of trade in the metropolis (Berry, 1960). The amount or proportion of trade lost through centralization is some function of distance from the metropolis.[10] The concept of usurption

of trade through centralization differs from trade activity in the classical central place system in that in the latter instance trading strength increases upward through the hierarchy because of the increasing number of higher-order functions performed by the larger centers (Christaller, 1966). Thus, the distinguishing feature between trade strength of urban centers proximate to a metropolis and those of a central place system is that the former is based on a relationship between strength and distance from a metropolis, whereas the latter derives from a relationship between strength and size. Using a per capita measurement for post office revenues is helpful for determining whether functional usurption of trade exhibits a relationship characteristic of a central place system or of metropolitan centralization.

In analyzing changes in the data it is often helpful to transform the variables to percentages whenever possible or practical. This tends to increase the symmetry of the variables' distribution and, therefore, the linearity of their relationship with other variables (Logan, 1970), thus facilitating easier interpretation of further analyses. Changes of auto ownership, labour force participation rates, per capita post office revenues, and population or growth rates, between 1961 and 1971 are all expressed in percentages. Finally, the growth of the housing market is indexed by the percentage of new dwellings built after 1961. In essence, this percentage measurement expresses the ratio of newly constructed housing units to the existing housing stock in percentage terms. The higher the percentage figure, the greater is the ratio of newly constructed housing units

relative to the previously existing stock.

iv Urban Boundaries

A further consideration with regard to variable measurements involves the treatment of changes in the boundaries of urban centers between 1961 and 1971. Doubtless, the method of treatment will have a profound effect on the measurement of variables in the data set, and the dynamic variables in particular. The difficulties posed by shifting urban boundaries can be resolved in part by using the same areal units - enumeration areas -[11] for data collected in both 1961 and 1971. This method is similar to that employed by Lamb (1975) to minimize the effects of local decentralization or residential sprawl and to circumvent problems of dealing with boundary changes through annexation. However, utilizing this particular method is not satisfactory for purposes of the present study for two reasons. First, the urban centers in this study are considerably smaller than those used by Lamb,[12] and residential sprawl is considered to be rather negligible. Second, artificially expanding the 1961 urban boundaries to conform to the 1971 boundaries necessitates the inclusion of a rural population component. Since only the urban population is being considered in the present context, this would violate one of the essential preconditions of selecting urban population centers. Moreover, all but three of the urban centers under consideration experienced some degree of annexation of surrounding territories.[13] Thus, it is argued that population increases resulting from annexation were experienced by all these urban centers, thereby tending to minimize population increases accruing to any one center.

The preceding review has outlined the procedures involved in applying principal components analysis for the purpose of constructing an *index of development*. The study time period and selection and measurement of variables that comprise the data set from which the *index of development* is to be derived were also reviewed. In the next section, attention is focused on examining the way in which this *index of development* is used to test hypothesized relationships about variation in levels of development throughout the growth space of Edmonton.

## III. Variations in Levels of Development

To account for variations in levels of development throughout the growth space of Edmonton, as indexed by the factor scores generated by the principal components analysis, it is necessary to employ a statistical technique that seeks out and explains functional relationships between patterns. Linear regression analysis is the best statistical technique for such purposes both because of the explanatory power of the regression model and its ability to test for hypothesized functional relationships. The linear regression model has been widely used in the geographic literature for analyzing the degree and direction of correspondence among two or more spatial patterns or locational arrangements. The methods and applications of this technique in the geographic literature are reviewed in Thomas (1960), Robinson, et.al (1961), Russworm (1964), Chorley and Haggett (1967), Taaffe (1969), Gould (1970), Yeates(1974), Willis (1975), and Taylor (1977). A detailed exposition of the mathematics underlying the multiple regression

model can be found in such standard statistical textbooks as Blalock (1960), Draper and Smith (1966), King (1969), Davis (1973), and Hayslett (1976).

A. The Linear Regression Model

Linear regression is a general statistical technique that obtains the *best-fit* linear relationship between a dependent or criterion variable and one or more independent or predictor variables. This *best-fit* line defines the rate of variation in a dependent variable to be expected, given a unit change in the magnitude of one or more independent variables. The conventional regression equation that describes the best-fit line is derived by the method of *least squares*, in which the squared deviations from the regression equation are minimized. Consequently, the contribution of any number of independent variables to the overall linear relationship with the dependent variable can be assessed, while controlling for the effects of any other independent variables in the equation.

Two linear regression models are used in the present analysis: simple regression analysis; and multiple regression analysis. The equation of the simple linear regression model describes the form of the relationship between a dependent and independent variable, and assumes the general form:

$$Y = a + bX + e$$

where: 'Y' is the dependent variable; 'a' is the constant or 'Y' intercept' 'b' is the regression coefficient or slope of the best-fit regression line;

'X' is the independent or predictor variable; and 'e' is the residual explanation, and a stochastic variable, that is, the difference between the actual and estimated value of 'Y' for each occurrence, often referred to as the error in prediction. The direction and strength of the relationship between the dependent variable, 'Y' and the independent variable 'X', is indicated by the correlation coefficient, 'r', and the coefficient of determination '$r^2$', respectively. The 't' statistic denotes the probability that the relation between 'X' and 'Y' does not occur by chance.[14]

The equation of the multiple linear regression model is an extention of the simple model, in that it depicts the relationship between a dependent variable and a set of independent variables. The equation is often written as: $Y = a + b_1X_1 + b_2X_2 + b_3X_3 \ldots b_nX_n + e$
The elements are the same as those of the simple regression equation, only, in this case, there is a regression coefficient, $b_{1, 2, 3...n,}$ for each of the independent variables, $X_{1, 2, 3...n}$. The direction and overall strength of the equation can be ascertained by examining the multiple correlation coefficient, 'R', and the multiple coefficient of determination, '$R^2$', respectively. These statistics perform the same function as the 'r' and '$r^2$' statistics used in conjunction with the simple regression equation, in that they all denote the degree to which changes in a dependent variable can be predicted from changes in one or more independent variables.

B. Assumptions of the Linear Regression Model

Poole and O'Farrell (1971) note that the validity of the functional relationship expressed by the simple and multiple coefficient of determination

is contingent upon satisfying a number of assumptions:

(1) The sample must be drawn at random.

(2) There should be no error measurement of the values obtained for each independent variable and the dependent variable.

(3) The dependent variable and all independent variables must maintain a normal frequency distribution when the sample is small.

(4) The variance of the 'Y' values about the regression line should not be significantly different as sample size varies. This is often referred to as the assumption of homoscedasticity.

(5) The relationship between the dependent variable, 'Y' and the independent variables 'Xn', must be linear.

(6) The residual values of 'Y' must be independent of each other. When this assumption is violated, the variables are said to be autocorrelated.

(7) In a multiple regression, in which two or more independent variables are utilized, the independent variables should be linearly independent of each other. When this assumption is not met, multicollinearity is present.

i Treatment of the Assumptions in the Literature

Although the assumptions of the regression model are of varying importance, depending on the purpose of the analysis (King, 1969), the extensive use of the model in the geographic research has largely ignored all but a few of these assumptions (Colenutt, 1968; King, 1969; Poole and O'Farrell, 1971; Taylor, 1977). There are, for example, few explicit

references to the assumption that the sample is drawn at random[15] and that there is no error measurement in the data; in most cases, these assumptions are taken for granted. The assumption of normality is often difficult to satisfy, and when variable transformation[16] is used to achieve normality, the observed relationship, and thus the model, become more difficult to interpret (Gould, 1970). Whereas normalizing data through transformation often helps to satisfy the assumption of homoscedasticity, little attention has been given to this assumption. Moreover, in cases where transformation achieves greater homoscedasticity (Berry and Barnum, 1962), there is no criteria to indicate the greater the degree of accuracy of the obtained results (Quarmby, 1967). Transformations are also useful for complying with assumptions of linearity among the dependent and independent variables (Haggett, 1965). This assumption is recognized in most of the geographical literature, and since the form of the function may not always be the best, different types of data transformations have been applied.[17]

Testing for the presence of autocorrelation is a straightforward procedure, though it is rarely carried out in geographical analysis (Dacey, 1968). The procedure simply requires that the residuals be subjected to a regression analysis and that the resultant correlation coefficients be examined to ascertain the degree of autocorrelation. Compliance with the assumption that the residual values of 'Y' are independent becomes more important when dealing with spatial relationships. In a geographical context, this characteristic of residual independence should hold over space. When this assumption is not met, spatial autocorrelation is present.

When two or more independent variables are not linearly independent of each other, multicollinearity is said to be present. Possible violations of this assumption are well recognized in the geographical literature, as evidenced by the fact that most researchers examine their correlation matricies to ensure that the variables are largely independent of each other and that there is a minimal amount of multicollinearity. If either multicollinearity or autocorrelation is present in the data, serious problems may arise, such as imprecise estimation of regression coefficients, possible distortion of absolute values, or instability of results obtained (Blalock, 1963). Often, these problems can be ameliorated by transforming the data, a procedure used to satisfy assumptions of normality and homoscedasticity.

The foregoing review of literature on the assumptions underlying the linear regression model underscores both the unsatisfactory treatment of these assumptions and the apparent deficiencies in the empirical application of the model. Indeed, Poole and O'Farrell (1971), in an extensive review of the way in which the assumptions of the linear regression model are treated throughout the geographical literature, suggest that,

> there appears to be some need for a paper whose objectives are to state clearly to geographers the assumptions of the regression model, to indicate how these assumptions may be tested for and to describe alternative models which may be used when certain assumptions are not satisfied. (Poole and O'Farrell, 1971, p. 151).

Since violation of one or more of these assumptions could well render inaccurate or misleading the results of the regression analyses, treatment of these assumptions, in the present analytical context, is discussed

below.

ii Treatment of the Assumptions in the Present Analyses

Arguments for using all of the urban centers in the growth space of Edmonton have been previously cited. Although this cannot be considered as a random sampling method, compliance with the latter would necessitate devising a new set of criterion which would be more difficult to apply and analyze in the present context. While the occurrence of measurement error among the variables in the data set can result in biased estimates of the regression coefficients, it is not possible to determine the degree of error involved in measuring the variables, because the amount of error is unknown. In fact, measurement error is often ignored because it is much less significant than error resulting from incorrect equation specification (Malinvaud, 1966, p. 362). Finally, since measurement error is assumed to be constant throughout (Johnston, 1963, pp. 150-162), its effects on the regression coefficients are considered to be negligible.

Meeting the assumption of normality among the variables in the present data set is important because of the relatively small sample size. Establishing confidence intervals or limits for each of the regression coefficients, and calculating interval estimates for predicting values of 'Y' corresponding to specific values of '$X_i$', rely on the commonly used students 't' and Snedecors 'F' statistical tests.[18] Since these tests require that the data are normally distributed, the data are transformed to their common logarithm. This logarithmic transformation not only

enables the data to approximate a normal distribution, but, also, tends to increase the explanatory power of the coefficient of determination, '$r^2$'. Both the frequency distributions of the transformed variables and their explanatory power are subsequently investigated.

Testing for the presence of non-linearity, heteroscedasticity, and spatial autocorrelation is not carried out because the data are transformed to their common logarithm prior to analysis. Data transformation is one of a number of possible solutions that can be applied to satisfy all of these assumptions. Other possible solutions for each of these assumptions are not considered in the present analysis because they involve extensive and intricate computations that would greatly complicate the analysis and interpretation of results obtained. Nonetheless, it should be pointed out that while data transformation does not ensure absolute compliance with each of these assumptions, it provides the best solution for purposes of the present analysis, given the difficulties involved in using other possible solutions.

The last assumption applies only to the multiple linear regression model. It states that the independent variables '$X_i$', used in the analysis must be linearly independent of each other. If this assumption is violated the independent variables are said to be multicollinear, and the result is that the individual regression coefficients are not identifiable. Multicollinearity is thought to pose serious problems when pairwise correlations are in excess of 0.80 (Hauser, 1973, p. 152), or when such

pairwise correlations are greater than the multiple correlation coefficient for the equation as a whole (Klein, 1962, p. 101). The presence of multicollinearity in the variables used in the present analysis is subsequently investigated.

Despite possible inadequacies with regard to the assumptions of the model, linear regression analysis is preferred as the best technique for analyzing and explaining variation in the levels of development throughout the growth space of Edmonton. The variables used in the analysis are described in the following section.

## C. Variables used in the Regression Analyses

### i Dependent Variable

The level of development (DEVLEVEL) of each urban center throughout the growth space of Edmonton is treated as the dependent variable. This variable is to be derived from corresponding factor scores obtained by the extraction of factors in the principal components analysis. These factors or components are to be comprised of various measures of development that will be used to construct the *index of development* (Table 4-1). The factor scores embody those development phenomena that are highly interrelated in time and space. These scores therefore represent the relative level of development of each urban center, based on the *index of development* component(s).

ii Independent Variables

(1) The distance of an urban center from Edmonton (LOGKLMS) is used as an independent or predictor variable to assess Edmonton's impact on levels of development of urban centers in the surrounding growth space. It is hypothesized that development levels are inversely related to the distance of an urban center from Edmonton, that is, as distance increases, Edmonton's impact decreases, resulting in a corresponding decline in development level (Hypothesis 1, Chapter One). The theoretical basis for this hypothesized relationship derives largely from the work of Logan (1970), Berry (1970a, 1970b, and 1973a), Robinson and Salih (1971), Moseley (1973b, and 1974), Lamb (1975), and Hansen (1976). The findings of these studies suggest that the impact of a large metropolis on a surrounding area or hinterland is a function of distance decay, and that location relative to a metropolis is a major factor determining levels of development in the surrounding growth space.

Distance is measured in kilometers from Edmonton along the fastest possible route.[19] For purposes of analysis, the common logarithm of distance is used, the effects of the friction of distance being typically curvilinear in nature (Olsson, 1965; Berry, 1969). As well, these logarithmic transformations help ensure compliance with a number of assumptions of the linear regression model. Moreover, a

comparison of the distance and the log of the distance used in the analyses confirmed the greater explanatory power of the latter.

(2) The population of an urban center in 1971 (LOGPOP71) is treated as a second independent or explanatory variable. Previous work by Alonso (1968a, 1968b, and 1971), Berry and Niels (1969), Berry (1970a, and 1973a), Richardson (1972) and Bourne (1975) emphasizes the importance of size and hierarchical position as a factor determining levels of development. In the present study, it is hypothesized that variation in development levels can be explained, in part, by the population of an urban center, that is, there is a positive relationship between urban population and development levels (Hypothesis 2, Chapter One). Once again, a logarithmic transformation on the variable is carried out for purposes of analysis.

(3) A further consideration involves the hypothesized effect of commuting (COMM71) on development levels. The findings of work by Berry (1968a, 1970a, and 1970b), Nichols (1969), Moseley (1973b, and 1974) and Hansen (1976) indicate that areas of *upward transition*, characterized by high levels of development are confined to the metropolitan commuting hinterland (Hypotheses 3 and 4, Chapter One). The commuting hinterland of Edmonton is comprised of those urban centers in which levels of commuting exceed 10%, this being the minimum proportion of the population necessary to

ensure that the favourable effects of commuting are evidenced in the development levels of the particular urban center (Morrill, 1973, p. 23). To test these hypotheses, two additional sets of regression analyses are carried out: one set of analyses uses only those urban centers within the commuting hinterland of Edmonton; the other set of analyses uses those urban centers that lie beyond the commuting hinterland. A comparison of the two sets of analyses is then made to determine whether there are significant differences between the explanatory power of the distance and size variables used to explain or account for levels of development of urban centers.

## IV. Summary

The present chapter detailed the quantitative techniques and procedures that will be used to empirically test the series of linked hypotheses outlined in Chapter One. First, a principal components analysis was presented as the most appropriate technique for constructing an *index of development*, and relevant aspects of the factor model were examined. The selection of original variables used to derive the *index of development* was reviewed and problems of variable measurement were discussed. Second, application of a linear regression model was proposed to explain variations among levels of development measured by the *index of development*. In addition to a description of the model, the assumptions of linear regression were considered and the treatment of these assumptions in the present analysis

was discussed. Finally, variables used in the regression analyses were explained. The analyses and analytical results are presented in the next chapter.

## Chapter Four Footnotes

1. This assumption and others are detailed in a later section of this chapter.

2. Other factor models are factor analysis, image analysis, canonical analysis, and alpha analysis. For detailed discussion of the various factor models see Rummel (1970) and Harman (1973).

3. Standardizing the data involves presenting them as *standard scores*. The mean thus becomes zero, the standard deviation is one, and all data are expressed in terms of their dispersal - positive or negative - about the mean.

4. An *eigenvalue* measures the amount of variation accounted for by a pattern. It is derived by summing the column of square loadings for each factor.

5. More recent information from the 1976 Census of Canada is not available. Moreover, the bulk of the data required for the present study is not published in the abridged Census of either 1976 or 1966.

6. The relation between newspaper circulation and urban markets was first examined by Park (1929).

7. The average cost of living for all items in 1971 was 100.0, whereas the figure for 1961 was 75.0. In other words, the cost of living in 1971 was 33% higher than in 1961. Thus, all variables measured in

dollars for the year 1961 are multiplied by 1.33 to account for or remove the effects of inflation.
Statistics Canada, Consumer Price Index, Catalogue 62-001, Vol. 55, No. 2, February, 1977, p. 6.

8. Tenure, as defined by the 1971 Census of Canada: "Refers to whether a private occupied dwelling was owned or rented by some member of the household". Census of Canada, Households, Introduction to, Volume II (Part I), Catalogue 93-701, Vol. II - Part I, (Bulletin 2.1-1), May, 1977, p. 40.

9. Labour force, as defined by the 1971 Census of Canada: "Refers to non-inmates, 15 years and over, who, in the week prior to enumeration, worked for pay or profit, helped without pay in a family business or farm, looked for work, were on temporary lay-off, or had jobs from which they were temporarily absent because of illness, vacation, strike, etc. Persons doing housework in their own home or volunteer work only, are excluded from the labour force".
Participation rate, as defined by the 1971 Census of Canada is "the percentage the labour force forms of the population 15 years and over in the category or area".
Census of Canada, Labour Force and Individual Income, Introduction to, Volume III (Part I), Catalogue 94-701, Vol. III - Part I, (Bulletin 3.1-1), November, 1976, p. 20.

10. The trading strength of an urban center proximate to a metropolis may increase or decrease through functional specialization, though the overall effects of this phenomenon on the trading strength of an urban center are less clear.

11. The basic unit for data collection is the enumeration area. See Appendix III (A) and III (B).

12. Urban centers used in the study by Lamb (1975) range in population from less than 2,500 to over 500,000, that is, from rural population centers to SMSA's respectively - as defined by the American Census.

13. Census of Canada, Population, Census Subdivisions (Historical), Catalogue 92-702, Vol. I - Part I, (Bulletin 1.1-2), July, 1973, pp. 2-106 to 2-109.

14. In essence, the 't' statistic tests the null hypothesis, that there is no significant relation, at a specified level of probability.

15. With regard to random selection, it is important to distinguish between two distinct models, each of which is expressed in the general form of the simple and multiple regression equations. The essential difference between these two models derives from the nature of the independent variable, 'X': in one case, the 'X' values are selected at random; in the other case the 'X' values are controlled at fixed values. The former is termed the "random X" model and the latter is referred to as the "fixed X" model (Poole and O'Farrell, 1971, p. 147). It was with reference to the "random X" model that the term 'regression' was originally used (Snedecor, 1956, pp. 152-162). This model is used in the present analysis.

16. There are two basic kinds of data transformations used to normalize data: one involves taking the common log of the data; the other uses the natural log. When a logarithmic transformation normalizes a distribution, the variable is described as lognormal.

17. A curvilinear relationship can be expressed in linear form by transforming one or more of the variables. Transformation into either common or natural logarithms of both variables will produce a linear form of any exponential curve (Yeates, 1974, pp. 80-82).

18. For a review of these tests see Yeates (1974, pp. 61-66, 133-139).

19. Distance measurements were taken along primary highways whose average speed limits range from 80 kilometers per hour (50 miles per hour) to 100 kilometers per hour (65 miles per hour).

# CHAPTER FIVE

# FACTORS UNDERLYING THE FORM OF DEVELOPMENT LEVELS

## I. Introduction

The first objective of the present study is aimed at constructing a composite "index of development" from a number of interrelated measures of development by means of a principal components analysis. This *index of development* is used to measure levels of development at urban centers throughout the growth space of Edmonton. The second objective is to determine the extent to which hypothesized factors of distance from Edmonton and urban center size explain variations among levels of development. The strength, direction and significance of the relationship between development levels and distance, on the one hand (Hypothesis One, Chapter One), and size, on the other hand (Hypothesis Two, Chapter One), are tested via linear regression analysis. The third objective involves ascertaining the hypothesized effect of commuting on the spatial form of development levels in the growth space (Hypotheses Three and Four, Chapter One). These hypotheses are also investigated by employing linear regression models. Each of the following sections outline the steps involved in the principal components analysis and various linear regression analyses, respectively, and details the analytical results.

## II. Measuring Levels of Development

Although there are numerous possible combinations of factor analytic procedures that can be employed to arrive at a particular solution, only those procedures that are relevant in each step of the present analysis are outlined.

### A. Correlation Matrix

The first step involves the calculation of the correlation coefficients for all of the original variables that comprise the data set. These correlation coefficients are contained in the correlation matrix (Table 5-1) that indicates the linear association between the variables. Inspection of the correlation matrix reveals that there are few correlation coefficients greater than 0.8, ensuring that none of the original variables are variants of each other (Hauser, 1973, p. 152). A more detailed examination of the correlation matrix indicates the presence of a large group or cluster of intercorrelated variables. All of the eight variables in this cluster have correlation coefficients of greater than 0.7 with two or more of variables in the cluster. Three sub-clusters can be identified for further investigation: INC71 (1), AMDV71 (2), TENURE71 (3), AUTO71 (4), DRYER71; (5), PCPO71 (9); and POP6171 (15), DWELLNEW (16). The first sub-cluster is comprised of static indicators of prosperity. Areas of high income, for example, display relatively high rates of amenity ownership as measured by autos and dryers, and have high housing prices associated with the predominance of owner-occupied residences. Similarly, areas dominated

Table 5-1

Correlation Matrix: Measures of Development

| | INC71 | AMDV71 | TENURE71 | AUTO71 | DRYER71 | LFPR71 | LT15YR71 | PCCIRC71 | PCPO71 | INC6171 | AMDV6171 | AUTO6171 | LFPR6171 | PCPO6171 | POP6171 | DWELLNEW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INC71 | | 81 | 61 | 82 | 76 | 76 | 66 | 45 | -79 | 35 | 60 | 11 | 44 | -13 | 64 | 68 |
| AMDV71 | | | 69 | 79 | 75 | 66 | 65 | 46 | -67 | 28 | 63 | 22 | 55 | -31 | 74 | 84 |
| TENURE71 | | | | 75 | 79 | 56 | 43 | 54 | -70 | 31 | 47 | 20 | 47 | -43 | 82 | 77 |
| AUTO71 | | | | | 83 | 62 | 49 | 51 | -79 | 25 | 56 | 20 | 41 | 17 | -65 | 62 |
| DRYER71 | | | | | | 68 | 43 | 45 | -75 | 21 | 50 | 09 | 35 | -13 | 56 | 56 |
| LFPR71 | | | | | | | 55 | 22 | -59 | 36 | 42 | 11 | 62 | -22 | 64 | 58 |
| LT15YR71 | | | | | | | | 28 | -61 | 24 | 25 | 05 | 36 | -02 | 60 | 69 |
| PCCIRC71 | | | | | | | | | -46 | -06 | 51 | 17 | 08 | -17 | 39 | 38 |
| PCPO71 | | | | | | | | | | -24 | -39 | -25 | -27 | 17 | -62 | -65 |
| INC6171 | | | | | | | | | | | 44 | 41 | 52 | -36 | 33 | 41 |
| AMDV6171 | | | | | | | | | | | | 20 | 15 | -21 | 41 | 46 |
| AUTO6171 | | | | | | | | | | | | | 33 | -38 | 17 | 21 |
| LFPR6171 | | | | | | | | | | | | | | -49 | 60 | 57 |
| PCPO6171 | | | | | | | | | | | | | | | -58 | -55 |
| POP6171 | | | | | | | | | | | | | | | | 90 |
| DWELLNEW | | | | | | | | | | | | | | | | |

by expensive dwellings are often owner-occupied, single-family dwellings with high rates of auto ownership and other amenities. Thus, as expected, there appears to be a considerable amount of intercorrelation between measures of prosperity.

These indicators of prosperity are inversely related with the second sub-cluster that indexes the volume of trading activity. It is noteworthy that all of the variables in the cluster have high, negative correlations with this sub-cluster of greater than -0.6. The strength and direction of this relationship provides tentative support for the contention that throughout the growth space areas with high levels of prosperity have corresponding low levels or volumes of trade activity, suggesting that functional usurption of these activities by the center or core - Edmonton - may be taking place.

The third sub-cluster is comprised of two highly intercorrelated variables whose correlation coefficient of 0.9 indicates the strong relation between population growth and new housing units. While the strength and direction of this relation is not unexpected, it is noteworthy that this sub-cluster is highly related with the measures of prosperity of the first sub-cluster. Both population and housing growth correlate quite highly with housing characteristics - average median dwelling value for 1971 and owner-occupied housing in 1971, and, to a lesser extent, with average incomes and auto ownership in 1971. This implies a relation between population and housing growth, on the one hand, and population growth and high levels of prosperity, on the other hand. Moreover, the relatively

high negative correlations between growth and trading volume provides further support for the contention that growth and prosperity are related. Whether in fact this growth is taking place in, or is giving rise to, high levels of prosperity cannot, however, be ascertained on the basis of this preliminary evidence; consideration of this cause-effect relationship requires more rigorous empirical analysis.

B. Factor Matrix

The second step involves transforming the original variables into a new set of composite variables on the basis of interrelations exhibited in the data. These new variables, termed factors or components, are exact mathematical transformations of the original data, and no particular assumptions about the underlying structure of the variables are required. The factors are orthogonal to each other, ensuring that each successive factor accounts only for that percentage of the variation not explained by the preceding factor(s). The primary purpose for constructing the factor matrix is to explore data reduction possibilities. Thus, only those factors that have an eigenvalue greater than 1.0 and explain more than five percent of the variance are extracted for further investigation. These extracted factors are presented in Table 5-2 along with their respective eigenvalues and associated percent of variation. Only loadings greater than 0.4 are presented to facilitate easy interpretation of possible patterns in the data (Logan, 1970; Moseley, 1973b).[1]

Examination of the factor matrix reveals that the first factor accounts for over one-half of the variation in the entire data set. The other three

Table 5-2

Factor Matrix: Variable Loadings on the First 4 Factors

| | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|---|
| INC71 | 88* | | | |
| AMDV71 | 91* | | | |
| TENURE71 | 86* | | | |
| AUTO71 | 86* | | | |
| DRYER71 | 81* | | | |
| LFPR71 | 78* | | | |
| LT15YR71 | 67* | | -42 | |
| PCCIRC71 | 53 | | 58* | |
| PCPO71 | -81* | | | |
| INC6171 | 45 | 58* | | 53 |
| AMDV6171 | 62* | | 44 | |
| AUTO6171 | | 53* | 43 | |
| LFPR6171 | 61* | 53 | | |
| PCPO6171 | -42 | -69* | | 40 |
| POP6171 | 86* | | | |
| DWELLNEW | 88* | | | |
| EIGENVALUE | 8.45 | 1.89 | 1.23 | 1.04 |
| % VARIANCE | 52.80 | 11.80 | 7.70 | 6.50 |

* Highest Variable - Factor Loading
(Decimal Points and Loading Below 0.40 Omitted)

factors extracted for further consideration together account for just over one-quarter of the variation, or approximately one-half of the variation accounted for by the first factor alone. The unusually large amount of variation accounted for by the first factor can be explained by the high variable loadings. The loadings contained in the factor matrix can be interpreted as correlation coefficients between the original variables and the factors, indicating the degree and direction of relationship of the variables with the patterns subsumed by the factors. All but one of the sixteen original variables have loadings on the first factor in excess of 0.4. The second factor has four loadings greater than 0.4; the third and fourth factors have similar loadings of four and two respectively. Moreover, twelve of the sixteen variables have their highest loading on the first factor while only three of the highest loadings occur on the second factor and one on the third factor.

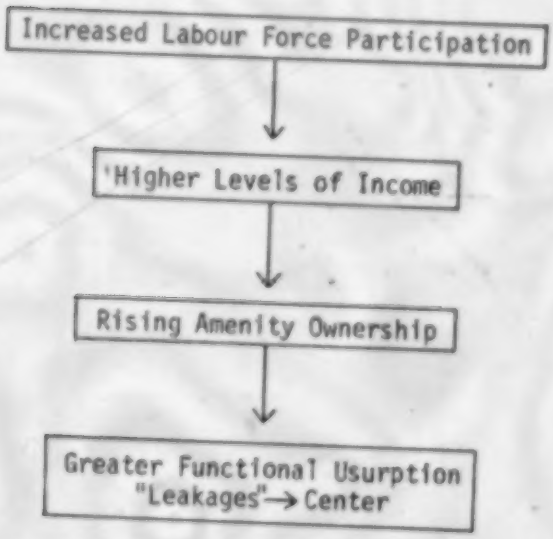
The foregoing investigation of data reduction possibilities underscores the prominence of the first factor or principal component, and suggests that data reduction can be achieved by utilizing only the principal component. These results are, however, only preliminary in that data reduction also requires proper interpretation of the factors or components on the basis of the variables from which they are constituted. The degree to which each variable is associated with each factor is indicated by the factor loadings or correlation coefficients which can be used to interpret the factor. Attention is now focused on interpreting the factors in an attempt to provide descriptive labels that reflect the nature of the phenomena involved in the factor patterns.

The first or principal component displays very high correlation coefficients of greater than 0.8 with the eight variables identified as a distinct intercorrelated cluster in the correlation matrix. These variables represent a number of interrelated aspects or measures of development: prosperity or affluence, as indexed by INC71, AUTO71, and DRYER71; housing characteristics, as depcited by AMDV71 and TENURE71; "functional usurption" of trade activities, coincident with developmental spread, as measured by PCPO71; and a corresponding dynamic element of population and housing growth. This component also indexes high levels of "population activity" as evidenced by the moderately high loadings of LFPR71 and LT15YR71. As well, all but one of the five remaining dynamic variables have loadings in excess of 0.4, as does the variable of PCCIRC71. Thus, this component is clearly an *index of development* in that it incorporates all measures of development and, in particular, those associated with material prosperity, population growth and housing expansion.

The other extracted components are harder to interpret. The second component exhibits moderately high correlation coefficients with INC6171, AUTO6171, LFPR6171, and PCPO6171. This component appears to index aspects of developmental spread in a causal sequence (Figure 5-1); increases in labour force participation give rise to higher levels of income; rising auto ownership results from increased income; and, functional usurption increases because of greater income leakages back to the center. Although this causal sequence suggests a trend of developmental spread, there is no evidence to indicate a corresponding increase of population growth and housing expansion. If in fact such a trend is discernible it should be

Figure 5-1

Possible Sequence of Developmental Spread



made manifest in increases in one or more of the measures of population and housing. The absence of these measures in the pattern subsumed by this component casts doubts on the contention that this component describes an underlying trend of developmental spread.

Variable loadings on the third component include LT15YR71, PCCIRC71, AMDV6171, and AUTO6171. There is no apparent explanation for the "pattern" described by this component. The moderately high loadings of PCCIRC71 may be accounted for by the negative loadings of LT15YR71, in that per capita newspaper circulation tends to rise as the proportion of the population under fifteen declines. However, there is no relation between these loadings and increases in both average median dwelling values and household auto ownership; and the latter, by themselves, do not denote an identifiable pattern or trend.

Finally, INC6171 and PCPO6171 display loadings in excess of 0.4 on the fourth component. These loadings would appear to indicate that, contrary to centers characterized by developmental spread, increased purchases resulting from rising incomes are not usurped by Edmonton. This suggests that centers scoring high on this component are probably located at a considerable distance from Edmonton beyond which direct competition and, therefore, functional usurption is minimal. Corresponding factor scores for this component do not, however, support this argument. This, coupled with the relatively low number of significant loadings - only two loadings greater than 0.4 - is insufficient to ascribe an appropriate label to the component.

Based on the foregoing examination of the type, strength and number of loadings on each component, it was decided that the objective of data reduction could be achieved by considering only the first or principal component for further investigation. This decision derives primarily from the inability to provide descriptive lables for the "patterns" subsumed by the latter three components, resulting in the immediate exclusion of almost one-half of the variance initially introduced into the analysis. However, the ratio of variance explained to variance unexplained is largely a function of the selection of original variables and appears less important than the identification of a composite index which both relates comprehensively to most of the original variables and is relevant in a theoretical context. Moreover, the unusually high percentage of variation accounted for by the principal component ensures a minimal amount of information loss in the data reduction process.

C. Factor Scores

Examination of the relevant aspects of this principal component that indexes levels of development throughout the growth space of Edmonton focuses on the factor scores. In essence, the factor scores are composite scales that represent the theoretical dimensions associated with the respective components. Each observation is assigned a score on the pattern described by the particular component. In the present analysis, each urban center receives a score on the principal component that can be interpreted as measuring the level of development of the urban center (Harman, 1960; Rummel, 1967). Table 5-3 contains the factor scores[2] on this component for

Table 5-3

Factors Scores of the *Index of Development*

| Center | Level of Development |
|---|---|
| Sherwood Park | 2.22 |
| St. Albert | 1.98 |
| Spruce Grove | 1.19 |
| Leduc | 0.55 |
| Fort Saskatchewan | 0.70 |
| Morinville | -0.09 |
| Stony Plain | -1.52 |
| Devon | -0.79 |
| Redwater | 0.57 |
| Wetaskiwin | 0.08 |
| Tofield | -1.08 |
| Westlock | -0.74 |
| Camrose | -0.36 |
| Vegreville | -1.47 |
| Ponoka | -0.15 |
| Barrhead | -0.25 |
| Lacombe | 0.12 |
| Mayerthorpe | -0.30 |
| Viking | -0.92 |
| Rimbey | -0.73 |
| Drayton Valley | 1.05 |
| Athabasca | -0.06 |

each urban center, indexing the relative level of development at each center.[3] The spatial distribution of these development levels is presented in Figure 5-2. These factor scores, and in particular, variations among the scores are examined in detail in the following section.

## III. Variation in Levels of Development

The principal components analysis proved helpful in that it was able to isolate a meaningful *index of development* that was then used to measure development levels at urban centers throughout Edmonton's growth space by means of the corresponding factor scores. This *index of development*, represented by the principal component, accounted for over one-half of the variance of the data set, and exhibited significant correlation coefficients of greater than 0.4 with all but one of the sixteen original variables. To gain a greater understanding of the various aspects of this principal component and to test hypotheses previously outlined in Chapter One, linear regression analysis is utilized. Specifically, the aim is to examine hypothesized relationships between levels of development and:

(1) distance from Edmonton (Hypothesis One, Chapter One);

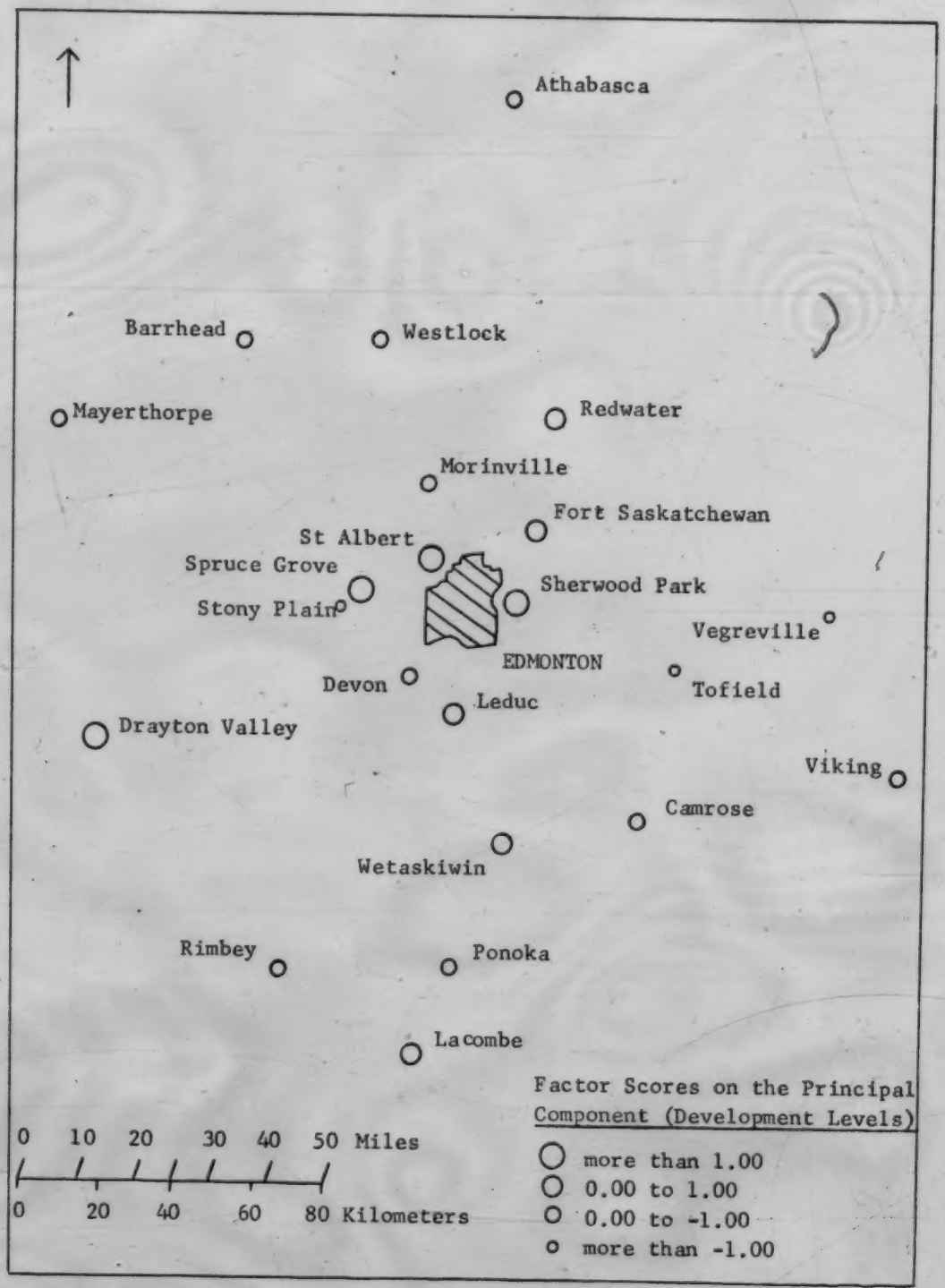
(2) urban center size (Hypothesis Two, Chapter One), and;

(3) both distance and size together.

As well, similar but separate analyses are carried out to test for differences in levels of development between urban centers characterized by high levels of commuting, greater than ten percent, and those with low levels of commuting; the purpose of these analyses is to ascertain whether there

Figure 5-2

Levels of Development of Urban Centers in the Growth Space of Edmonton



is a relationship between development and commuting levels (Hypothesis Four, Chapter One). Finally, the distribution of development levels of urban centers throughout the growth space of Edmonton is examined in order to determine whether the spatial form of this distribution is arranged concentrically around Edmonton (Hypothesis Three, Chapter One).

A. Distance and Size

Table 5-4 lists the sixteen original variables from which the *index of development* was derived and displays the correlation coefficients between each of these variables and the independent variables of distance and size. The table also sets out correlation coefficients between the *index of development* and both independent variables. From Table 5-4 it is apparent that the *index of development* and most of the variables which contribute notably to that index display significant negative correlations with distance from Edmonton and a significant positive correlation with urban center size - as hypothesized.

The results of regressing the *index of development* against the log of distance from Edmonton are presented in Table 5-5 and Figure 5-3. The coefficient of determination, $r^2$, is significant at the 95% level, hence, Hypothesis One - that development levels of urban centers decline with increasing distance from Edmonton, may be reasonably accepted. A second equation is obtained by regressing the *index of development* against the log of the population of each urban center (Table 5-6 and Figure 5-4). The $r^2$ value of 0.39 is highly significant at a level of greater than

Table 5-4

Correlation Coefficients: Size and Distance with Development Measures and *Index of Development*

| | LOGPOP71 | LOGKLMS |
|---|---|---|
| INC71 | 49* | -66*** |
| AMDV71 | 76*** | -79*** |
| TENURE71 | 34 | -74*** |
| AUTO71 | 50** | -73*** |
| DRYER71 | 58** | -66*** |
| LFPR71 | 52** | -38* |
| LT15YR71 | 47* | -54** |
| PCCIRC71 | -01 | -61*** |
| PCPO71 | -47* | 74*** |
| INC6171 | 05 | -20 |
| AMDV6171 | 21 | -51** |
| AUTO6171 | 19 | -15 |
| LFPR6171 | 40* | -33 |
| PCPO6171 | -07 | 28 |
| POP6171 | 40* | -63*** |
| DWELLNEW | 53** | -76*** |
| DEVLEVEL | 63*** | -55** |

* 95% significance level

** 99% significance level

*** 99.9% significance level

(Decimal points ommitted

Table 5-5

Regression Equation [1]: Levels of Development (DEVLEVEL) on Distance from Edmonton - log (LOGKLMS)

DEVLEVEL = 3.14 - 1.73 (LOGKLMS)

$r = 0.55$

$r^2 = 0.31$

Se = 0.85

df = 20

t = 2.04

significance level = 0.05

Figure 5-3

Best-Fit Line of the Relation Between Level of Development (DEVLEVEL) and Distance (LOGKLMS)

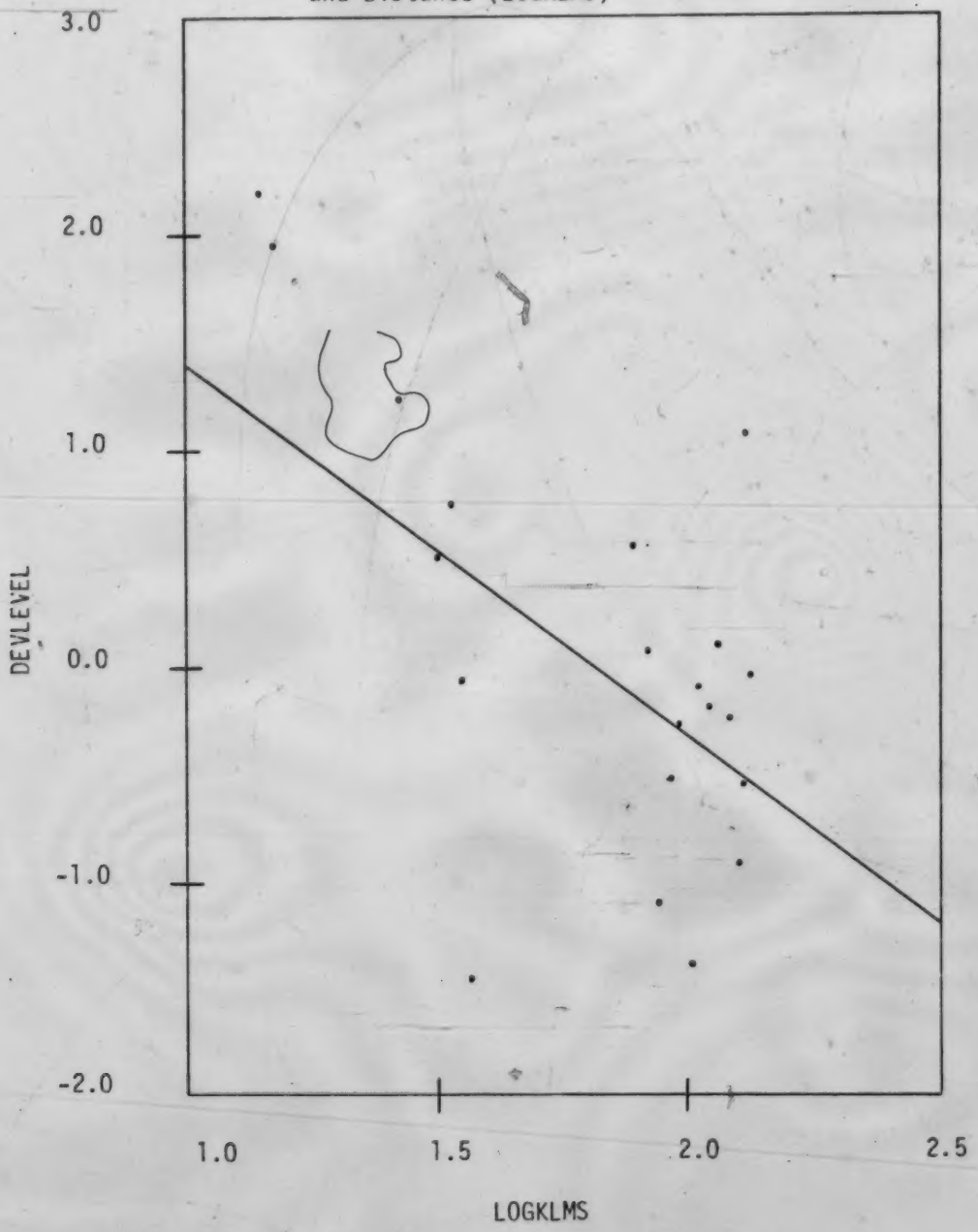


Table 5-6

Regression Equation [2]: Levels of Development (DEVLEVEL) on Urban Center Size - log (LOGPOP71)

DEVLEVEL = -6.36 + 1.83 (LOGPOP71)

$r = 0.63$

$r^2 = 0.39$

Se = 0.80

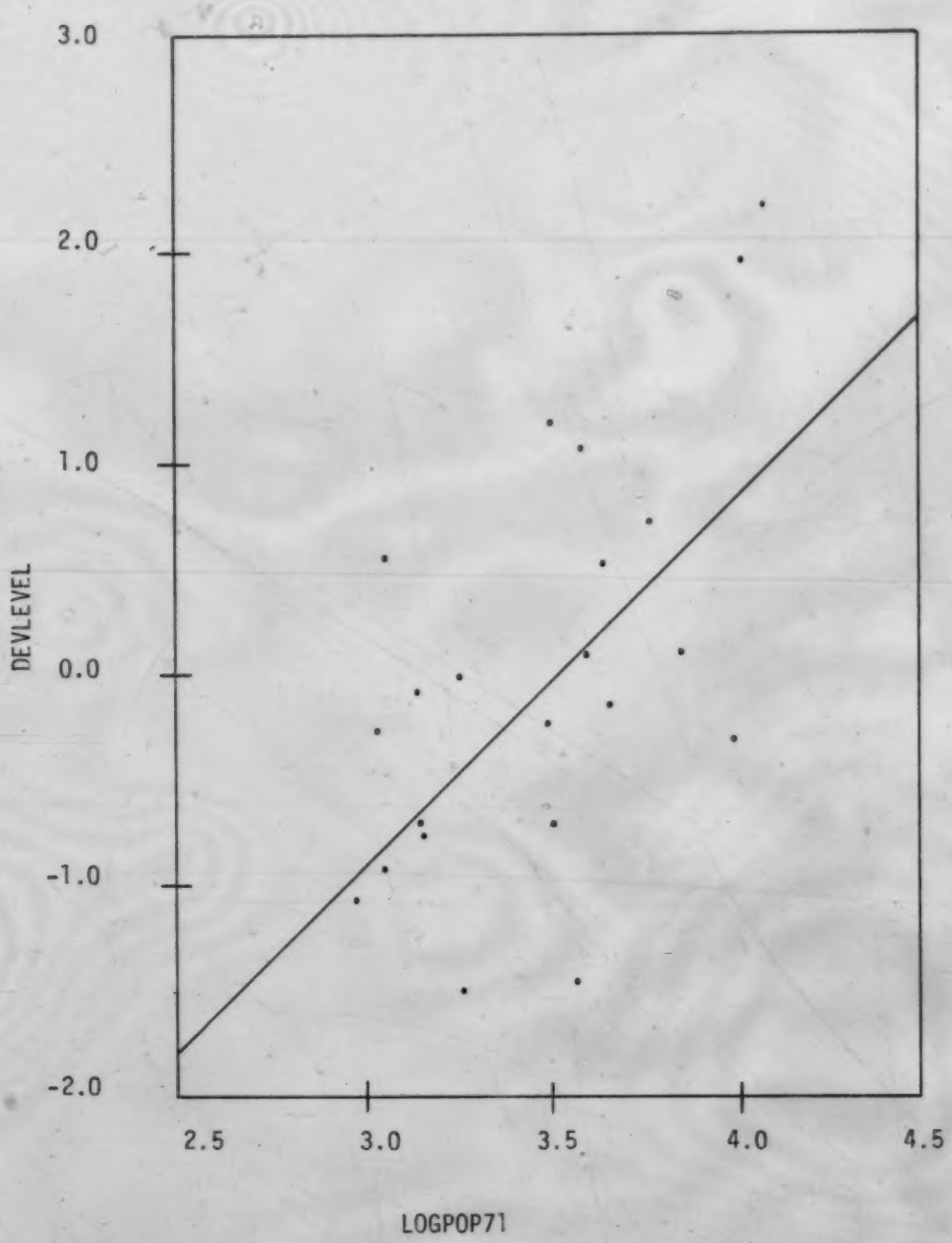
df = 20

t = 2.29

significance level = 0.025

Figure 5-4

Best-Fit Line of the Relation Between Level of Development (DEVLEVEL) and Size (LOGPOP71)



97.5%, and there is no reason not to accept the second hypothesis that development levels are related to urban size. Finally, a third equation can be generated by regressing the *index of development* on both distance and size, to ascertain the combined effects of the latter variables on the former (Table 5-7). The multiple linear regression is carried out via hierarchical inclusion of the two independent variables - first, distance, then size. This technique is employed because a correlation coefficient of 0.44 between distance and size suggests a causal ordering among the two variables in which distance affects size.[4] Both partial regression coefficients of distance and size contribute significantly at the 95% level to the overall relation with the dependent variable. The strength of this relation is reflected by the multiple coefficient of determination of 0.49, indicating that approximately one-half of the variation among levels of development of urban centers can be explained by the combined effects of distance and size.

B. Commuting and the Spatial Form of Development Levels

The foregoing analyses have not only substantiated the hypotheses that size and distance, both separately and together, significantly affect development levels but, also, have shown the degree to which these factors account for variations in development levels. Hypothesis Four, however, suggests that the overall significance of regression equations [1] to [3] derives primarily from those urban centers with high levels of commuting. Hence, further regression analyses are required to determine whether in fact commuting levels significantly affect the degree to which the factors

Table 5-7

Regression Equation [3]: Level of Development (DEVLEVEL) on Distance from Edmonton - log (DISKLMS) and Urban Center Size - log (LOGPOP71)

DEVLEVEL = -2.86 - 1.08(LOGKLMS) + 1.39(LOGPOP71)

(LOGPOP71) = 0.63

(LOGKLMS) r = -0.55

R = 0.70

$R^2$ = 0.49

Se = 0.75

df = 18

(LOGKLMS) t = 2.04

significance level = 0.05

(LOGPOP71)t = 1.85

significance level = 0.05

of size and distance account for variation in levels of development.

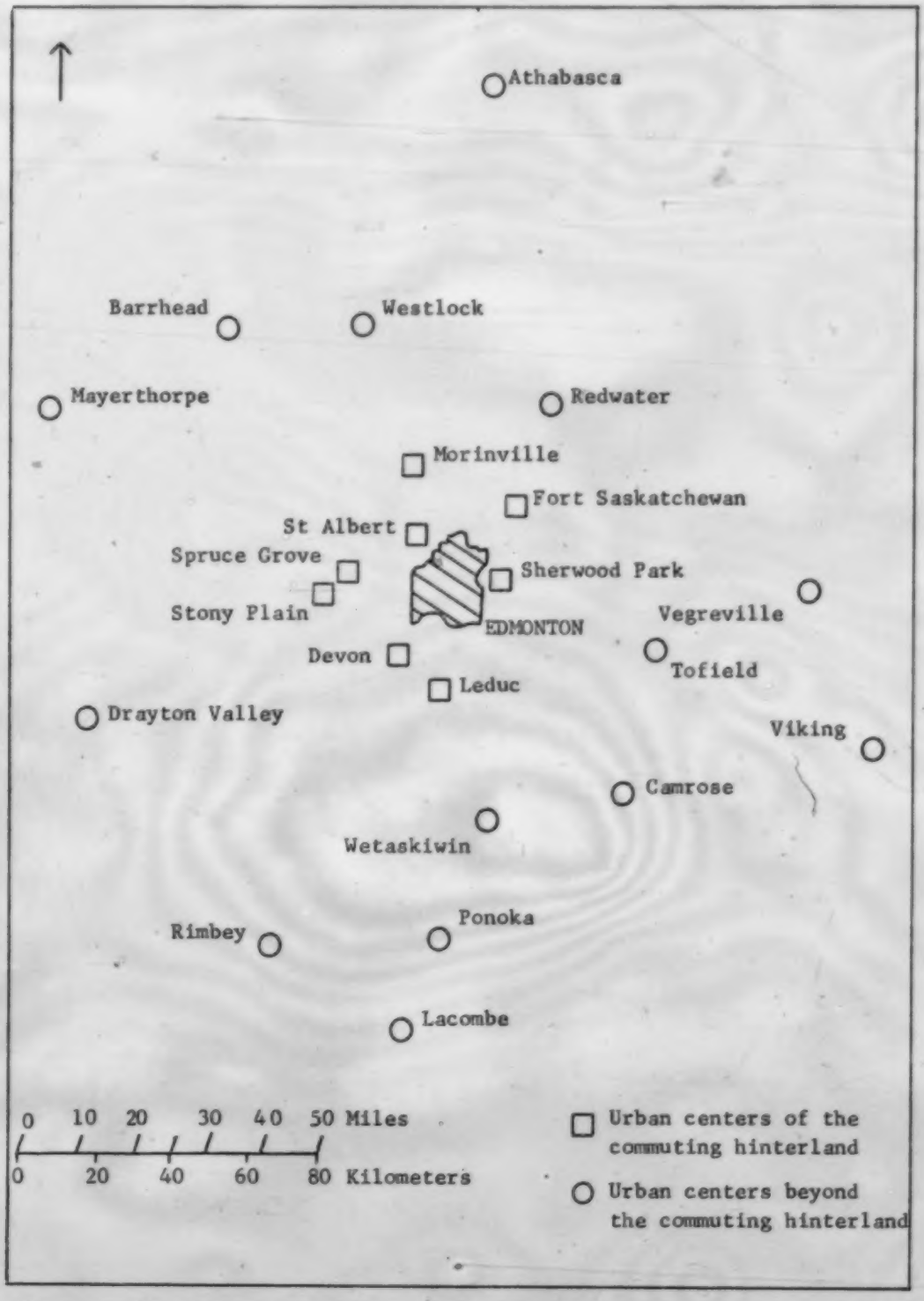
In order to ascertain the effects of commuting on the relationship between levels of development and (1) distance from Edmonton, and; (2) urban center size, the twenty-two urban centers in the preceding analyses are sub-divided into two groups. The criterion upon which a particular urban center is allocated to one of the two groups is based on the "critical" commuting level or threshold of 10%. This figure is the lower limit which Morrill (1973) argues is necessary to ensure that the positive or favourable effects of commuting are evidenced, and is the basis upon which the commuting hinterland of Edmonton is delineated. Eight urban centers comprise the group in which commuting levels exceed 10%; the remaining fourteen urban centers, all with levels of commuting of less than 10% are placed in a second group. For purposes of analysis, each group is treated as a separate sample.

Figure 5-5 shows the distribution of urban centers by sample. It is noteworthy that the sample of eight urban centers that comprise the commuting hinterland are all located within forty kilometers of Edmonton, while the other sample of fourteen centers with low levels of commuting all lie beyond sixty kilometers. This apparent relation is borne out by the high correlation of -0.88 between distance and commuting. The implication of the synonymity between distance and commuting, the independent or explanatory variables of Hypothesis Three and Four respectively, is that only one of the two hypotheses need be tested. The present analysis, however, attempts to test both hypotheses separately to ensure that the results of both analyses are consistant. Although this may give rise to

Figure 5-5

Distribution of Urban Centers Within and Beyond the Commuting Hinterland of Edmonton






Source: Adapted from sources in Figure 3-11.

some overlap, it is a good method for cross-checking or verifying the results obtained. This point will be discussed at greater length in a latter section of the present chapter; presently attention is focused on the analysis of the two samples whose results are presented, in turn, below.

Table 5-8 presents the correlation matrix used in the first set of analyses of urban centers in the commuting hinterland of Edmonton. Examination of the matrix reveals a very high correlation coefficient of -0.89 between the independent variables of size and distance. The presence of multicollinearity among these variables renders any results from a multiple linear regression analysis invalid; hence, the combined effects of distance and size on levels of development among urban centers with high levels of commuting cannot therefore be determined with much reliability. Since it is not possible to analyse the combined effects of the distance and size variables on levels of development, it was decided that variations associated with the latter could be largely explained by reference to one of the two independent variables. This decision is based on the high correlation coefficients between the *index of development* and distance (-0.85) on the one hand, and size (0.89) on the other hand. Results of regressing the *index of development* on (1) distance, and; (2) size are presented in Table 5-9/Figure 5-6, and Table 5-10/Figure 5-7, respectively.

Table 5-11 sets out the correlation matrix of variables used in the second set of analyses of fourteen urban centers with low levels of commuting. The correlation coefficients between the *index of development* and the independent variables of distance and size are so low as to account

Table 5-8

Correlation Coefficients: Urban Centers with High Levels of Commuting

| | DEVLEVEL | LOGKLMS | LOGPOP71 |
|---|---|---|---|
| DEVLEVEL | 1.00 | -0.85 | 0.89 |
| LOGKLMS | | 1.00 | -0.89 |
| LOGPOP71 | | | 1.00 |

Table 5-9

Regression Equation [4]: Levels of Development (DEVLEVEL)
on Distance from Edmonton - log (LOGKLMS)
for Urban Centers with High Levels of Commuting

DEVLEVEL = 10.14 - 6.68 (LOGKLMS)

$r = -0.85$

$r^2 = 0.72$

Se = 0.75

df = 6

t = 8.90

significance level = 0.001

Figure 5-6

Best-Fit Line of the Relation Between Level of Development (DEVLEVEL) and Distance (LOGKLMS) for Urban Centers with High Levels of Commuting

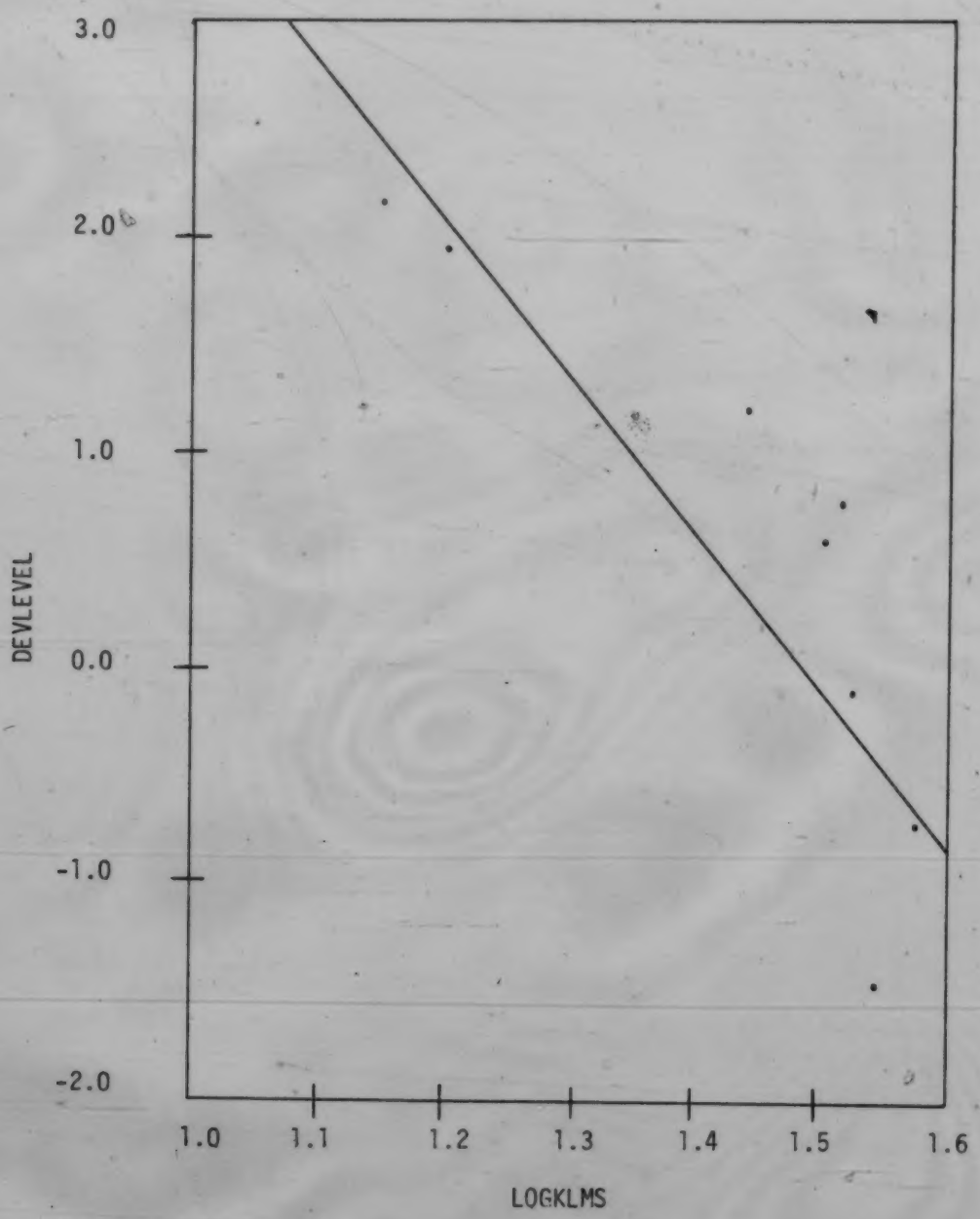


Table 5-10

Regression Equation [5]: Levels of Development (DEVLEVEL)
on Urban Center Size - log (LOGPOP71)
for Urban Centers with High Levels of Commuting

DEVLEVEL = -10.0 + 2.94 (LOGPOP71)

$r = 0.89$

$r^2 = 0.78$

Se = 0.65

df = 6

t = 4.65

significance level = 0.001

Figure 5-7

Best-Fit Line of the Relation Between Level of Development (DEVLEVEL) and Size (LOGPOP71) for Urban Centers with High Levels of Commuting

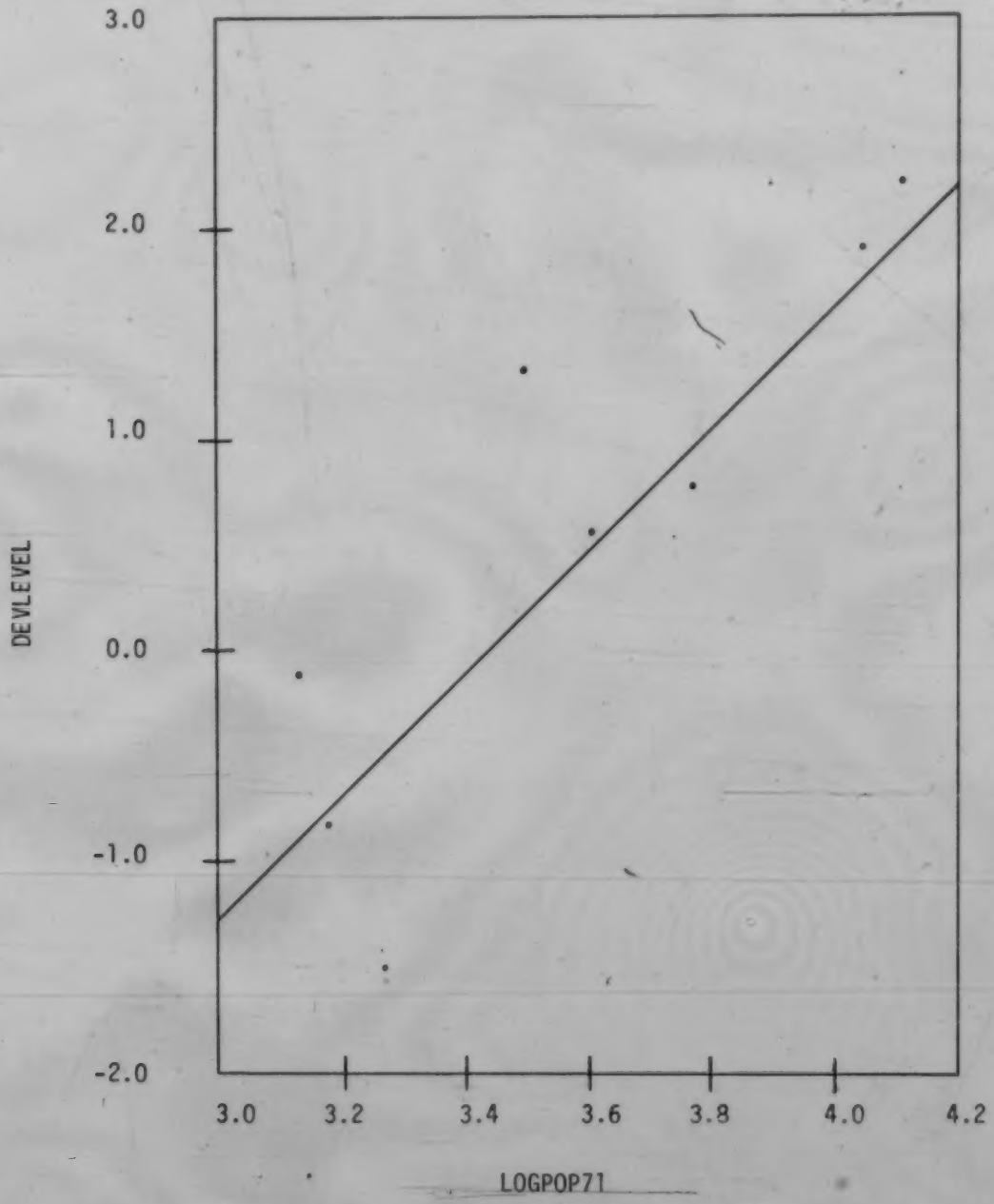


Table 5-11

Correlation Coefficients: Urban Centers with Low Levels of Commuting

| | DEVLEVEL | LOGKLMS | LOGPOP71 |
|---|---|---|---|
| DEVLEVEL | 1.00 | 0.02 | 0.22 |
| LOGKLMS | | 1.00 | -0.13 |
| LOGPOP71 | | | 1.00 |

for an insignificant proportion of variance. This poor degree of explanation is evident in the parameters of the equation in which the *index of development* is regressed on both distance and size (Table 5-12).

Given the poor explanatory or predictive power of the multiple coefficient of determination, $r^2$ and its insignificance, no further regression analyses are attempted.

On the basis of equations [4] and [5] it is apparent that development levels of the eight urban centers in the commuting hinterland can be explained or predicted with a fair degree of certainty by urban center size or distance from Edmonton. Concomitantly, variations in levels of development can be accounted for by either size or distance. The same, however, cannot be said of the fourteen urban centers that lie beyond the commuting hinterland, for as equation [6] clearly demonstrates, the effects of distance and size on levels of development are insignificant and their ability to account for variations in development levels are indeed limited. These findings indicate that levels of development at urban centers with high levels of commuting are significantly different than those in areas of low commuting, and more specifically, that high levels of development are essentially confined to urban centers located in the commuting hinterland of Edmonton. Indeed, the mean level of development of urban centers in the commuting hinterland is 0.53 compared to a mean of -0.30 for those urban centers that lie beyond the commuting hinterland. The difference between these two sample means is significant at the 90% level,[5] indicating that these two samples were most probably not drawn from the same population.

Table 5-12

Regression Equation [6]: Levels of Development (DEVLEVEL)
on Distance from Edmonton - log (LOGKLMS) and
Urban Center Size - log (LOGPOP71)
for Urban Centers with Low Levels of Commuting

DEVLEVEL = -2.47 + 0.23(LOGKLMS) - 0.49(LOGPOP71)

(LOGKLMS) r = 0.02

(LOGPOP71) r = 0.22

R = 0.22

$R^2$ = 0.05

Se = 1.50

df = 11

(LOGKLMS) t = 0.15

significance level = insignificant

(LOGPOP71) t = 0.33

significance level = insignificant

Based on this evidence it would not be unreasonable to accept both Hypotheses Three and Four. The former hypothesizes that the form of the growth space can be sub-divided into two areas, arranged concentrically around Edmonton: an inner area of *upward transition*, characterized by relatively high levels of development; and an outer zone of *downward transition*, reflecting lower levels of development. When treated as two separate samples - one containing urban centers with high levels of commuting and a second comprised of those urban centers with low levels of commuting - the average levels of development between samples is found to be significantly different. That is, those urban centers located in the commuting hinterland of Edmonton display relatively high levels of development that are significantly greater than those urban centers beyond the immediate commuting hinterland. While this evidence appears to substantiate Hypothesis Three, the exact spatial form of development levels in the growth space of Edmonton is, however, difficult to determine because of the small sample sizes. Moreover, the criterion of a 10% level of commuting upon which the twenty-two urban centers are divided into two samples is somewhat arbitrary and results may have differed markedly had other measures been used. Although the selection of the criterion of commuting is somewhat arbitrary, the decision is based on previous work by Berry (1968a, 1968b, 1970a, 1970b, and 1973a), Moseley (1973b, 1973c), and 1974), Hansen (1971, 1973a, 1975a, 1975b, and 1976) and others that emphasize the importance of the effects of commuting on development. Since this commuting criteria derives largely from a theoretical basis, there is no apparent reason not to accept the findings of the present analysis which

suggest that the spatial form of development levels in the growth space of Edmonton is arranged in a manner similar to that outlined in Hypothesis Three.

The latter hypothesis, four, relates areas of *upward transition*, characterized by high levels of development, to areas with high levels of commuting. The hypothesis that the area of *upward transition* is confined to the commuting hinterland not only suggests a direct relationship between development and commuting but, also, implies that there is a critical level or threshold of commuting below which this relationship does not hold. The results of the foregoing analyses support the hypothesized effects of commuting on development levels throughout the growth space of Edmonton. Equations [4] and [5] show that in urban centers where commuting exceeds 10% there is a strong and significant relationship between development levels and distance from Edmonton on the one hand, and urban center size on the other hand. Equation [6] shows that below the 10% commuting level no such relationship exists. As well, the *difference of means* test reveals that centers with high levels of commuting have a significantly higher average level of development than those centers with relatively low levels of development. Based on this evidence, Hypothesis Four can also be accepted with a fair degree of certainty.

## IV. Summary and Discussion of Analyses

### A. Further Considerations

The findings of the present study make no pretence at being complete.

While the foregoing analyses showed that variation among levels of development of surrounding urban centers in the commuting hinterland appeared to be largely a function of their distance from Edmonton or their size, variation among levels of development of the outlying urban centers beyond the commuting hinterland could not be explained by either their location relative to Edmonton or their size. This suggests that factors other than distance and size underlie the observed variation among development levels of the latter group of urban centers, and, of course, one could hypothesize a number of variables that might account for these variations. Logan (1970), for example, in a study that identified and attempted to explain spatial dimensions of regional economic development in the Upper Midwest, hypothesized that there was a correlation between certain occupations and levels of economic development. Logan used six occupational categories to test this hypothesis and found that the three urban-oriented occupations correlated positively with levels of economic development while two of the three agricultural-based occupations were inversely related to levels of economic development. In a later study of growth centers in the American urban system Berry (1973a) found that growth rates of different sized *Daily Urban Systems* throughout the United States between 1960 and 1970 were related to occupation structure; that is, certain broad employment pattern tendencies appeared to underlie the relationship between urban growth and size. These general patterns identified by Berry can be characterized in the following manner:

(1) The greater a *Daily Urban System's* dependence was on primary activities, such as agriculture, the lower its rate of growth, and

when agriculture accounted for over 25 percent of total earnings, there was an absolute population decline;

(2) The growth rates of manufacturing centers tended to stabilize around the national average;

(3) Trade or service-oriented centers exhibited higher rates of growth than the national average, and;

(4) Growth rates increased as the proportion of earnings derived from government increased.

The findings of Logan (1970) and Berry (1973a) indicate that the level of economic development and growth rate of an urban center(s) or region can be explained, in part, by the existing occupation profile or structure.[6] These findings appear to be relevant in the present context because a comparison between the surrounding and outlying urban centers showed that the latter had a higher proportion of their labour force engaged in primary activities such as agriculture, forestry and resource extraction.[7] An accurate assessment of this supposition within the context of the objectives of the present study, however, would almost certainly require a much more detailed and elaborate disaggregation of the various occupational aspects or components than that attempted by either Logan or Berry. Similarly, one could hypothesize the relevance of other independent variables, for example, one relating to the economic base, inter-industry linkages, or infrastructure of an urban center or region, whose inherent composition is considerably more complex than that of occupation. Since such considerations are beyond the scope of the present study, and would

only serve to detract from the purpose of testing hypotheses relating primarily to geographical location, these other influences upon the pattern of development are construed as *residual* in the present context.

The study findings are also lacking because the limited period of time for which useful data were available, essentially 1961 and 1971, precluded an empirical examination of the changing nature of locational determinants of growth and development. Restrictions imposed by the limited data base were compensated, in part, by using a variety of variables that incorporated a dynamic element which attempted to index change.[8] The study findings themselves also provided a basis for overcoming some of the deficiencies of the data base. These deficiencies related primarily to unavailability of comparable data beyond 1971 for development measures used to construct the *index of development*. It will be recalled, however, that:

(1) an examination of patterns and trends of population growth and development of urban centers in the growth space of Edmonton indicated significant correlations between population growth and various development measures (see Chapter Three), and;

(2) population growth exhibited a high loading on the *index of development*.

This evidence suggests a strong relation between development levels and population growth rates, and since data for the latter was obtained for 1976, a postdiction of development trends between 1971 and 1976, based on population data, is attempted.

Table 5-13 presents the population data for 1976 and the growth rates of urban centers from 1971 to 1976. Perhaps the most significant change is the decline of Edmonton's growth rate from 3.6% during the previous decade to just over 1.0% between 1971 and 1976. The pattern of growth rates that emerge from these data clearly underlines the continued and accelerated growth of urban centers in the commuting hinterland.[10] Indeed, the median average annual growth rate of urban centers in the commuting hinterland during this period was 17.7% compared to a similar rate of only 1.9% for outlying urban centers beyond the commuting hinterland. The obvious differences between these two groups is further illustrated by the fact that the lowest growth rate of 8.4% among the former group of urban centers was more than twice the highest growth rate of 4.2% recorded by an urban center in the latter group.

The major inference that can be drawn by extrapolating development trends from the population growth rates presented in Table 5-13 is that development levels of urban centers in the commuting hinterland have increased markedly, relative to development levels of urban centers beyond the commuting hinterland. In particular, the accelerated growth of the two furthest centers in the commuting hinterland implies that the level of development of these centers rose substantially between 1971 and 1976, and that these increases reflect development levels found in areas of *upward transition*. The population data also suggest a consolidation of the commuting hinterland, that is, the spatial extent of the area of *upward transition*, essentially confined to the commuting hinterland,

Table 5-13

Population and Population Growth of Edmonton and Urban Centers in the Growth Space, 1976

| Urban Center | Population 1976 | Population Growth* 1971-76 |
|---|---|---|
| Edmonton | 461,361 | 1.1 |
| Sherwood Park | 26,713 | 17.4 |
| St. Albert | 24,124 | 20.9 |
| Spruce Grove | 6,907 | 25.5 |
| Leduc | 8,576 | 22.9 |
| Fort Saskatchewan | 8,304 | 9.0 |
| Morinville | 2,097 | 8.4 |
| Stony Plain | 2,717 | 10.7 |
| Devon | 2,786 | 18.0 |
| Redwater | 1,493 | 3.2 |
| Wetaskiwin | 6,754 | 1.6 |
| Tofield | 1,120 | 4.2 |
| Westlock | 3,876 | 3.9 |
| Camrose | 10,104 | 3.3 |
| Vegreville | 4,158 | 2.5 |
| Ponoka | 4,636 | 1.0 |
| Barrhead | 2,944 | 1.0 |
| Lacombe | 3,888 | 1.6 |
| Mayerthorpe | 1,018 | -0.3 |
| Viking | 1,217 | 0.7 |
| Rimbey | 1,452 | 0.0 |
| Drayton Valley | 4,303 | 2.1 |
| Athabasca | 1,759 | 0.0 |

* Average Annual % change in population

Source: [9]

appears to be more clearly delineated, and the magnitude of Edmonton's impact on development levels of urban centers, via the labour market, appears to be more pronounced.

Firm conclusions regarding development trends in the growth space of Edmonton beyond 1971 await empirical verification. Nonetheless, the preceding postdictions, albeit largely based on conjecture, do provide an indication of possible development trends in the growth space of Edmonton. These apparent trends closely follow similar trends that have been taking place near metropolitan centers throughout the United States - continued rapid growth in exurban areas that maintained access to the metropolis via commuting, and rising levels of economic well-being that exceeded levels of well-being of the metropolis itself (Berry, 1977). These similarities and the evidence derived by extrapolating development trends from the population data strongly suggest that the locational determinants, identified in the empirical analyses, have continued to exert an increasing influence on the form of development levels in the growth space of Edmonton.

## B. Summary of Findings

The original data set of sixteen development measures or variables was reduced by means of principal components analysis which successfully isolated a meaningful *index of development*. This *index of development* accounted for 52.8% of the total variance contained in the original data set (Table 5-2), thereby minimizing the amount of information lost in the data reduction process. Factor scores derived from the *index of development*

were then used to measure levels of development at urban centers throughout the growth space of Edmonton (Table 5-3, Figure 5-2). A series of regression analyses were then carried out to test hypothesized relationships between levels of development and (1) distance from Edmonton; (2) urban center size, and; (3) effects of commuting. Two simple regression analyses, in which development levels were regressed first on distance and then size, provided evidence to support Hypotheses One and Two respectively. A multiple linear regression analysis of development levels on both distance and size together indicated that approximately one-half of the variation evidenced in the former was explained or accounted for by the two independent variables.

Another series of regression analyses was conducted to ascertain the degree to which commuting affected not only the hypothesized relationships outlined above but, also, the spatial form of development levels. These analyses clearly demonstrated that the overall significance of relationships expressed by equations [1], [2], and [3], derived mainly from those urban centers located in the commuting hinterland of Edmonton. Furthermore, variations in levels of development among these urban centers were explained or accounted for largely by their size or distance from Edmonton; however, no apparent explanation for variation of development levels among urban centers beyond the immediate commuting hinterland was discerned. Another difference between those urban centers with high levels of commuting greater than 10% and those centers with low levels of commuting was the average level of development. The "difference of means" test between these two groups

showed that the former had a significantly higher mean level of development than the latter, indicating that these two groups or samples were, in all probability, from different populations. This contention was also supported by the results of the regression analyses which showed that the high levels of development of urban centers in the commuting hinterland were largely a result of their size and proximity to Edmonton. In contrast, outlying centers with low levels of commuting exhibited low levels of development; the implication here is that the absence of a large proportion of commuters from these centers is a major factor underlying their low levels of development.

The major differences between these two distinct groups of urban centers, differentiated on the basis of commuting levels, are illustrated in Table 5-14. The eight surrounding centers had a median commuting level of 24.4% compared to 1.7% for the fourteen outlying centers; as previously noted, all eight surrounding centers had more than 10% of the labour force commuting to Edmonton, while none of the fourteen centers in the latter had commuting levels in excess of 10%. The mean level of development of 0.53 among urban centers of the first sample was shown to be significantly higher than the corresponding figure of -0.30 for the second sample. Finally, the median distance of urban centers from Edmonton in the first sample was significantly less than that of the second sample - 32 kilometers and 110 kilometers respectively (Table 5-14). All of the eight urban centers in the former sample were located within less than 40 kilometers of Edmonton, the approximate extent of the commuting hinterland, whereas

Table 5-14

Significant Differences Between Surrounding and Outlying Urban Centers*

| | Surrounding Centers (8 Centers) | Outlying Centers (14 Centers) |
|---|---|---|
| Median Level of Commuting | 24.4 | 1.7 |
| Average Level of Development | 0.53 | -0.30 |
| Median Distance from Edmonton (Kilometers) | 32 | 110 |

* Levels of Commuting of the 8 surrounding centers exceeded 10%; Commuting Levels of the 14 outlying centers were below 10%.

Source: Adapted from sources used in Table 3-3 and Table 3-11.

all fourteen centers in the latter sample were located beyond 60 kilometers.

The conclusions that can be drawn from the information contained in summary form in Table 5-14 support Hypotheses Three and Four. With regard to the former, the high levels of development in urban centers within 40 kilometers of Edmonton and the low levels of development among urban centers beyond 60 kilometers suggests that the spatial distribution of development levels around Edmonton is somewhat analagous to the center-periphery model in which an area of "downward transition" lies beyond an area of "upward transition". Hence, Hypothesis Three, which denotes the general form of development levels around Edmonton, can be reasonably accepted. With regard to Hypothesis Four, the "difference of means test" clearly showed that the first sample had significantly higher levels of development than the second sample. Since the former sample was comprised of urban centers with levels of development greater than 10%, there is no reason not to accept Hypothesis Four which states that high levels of development, characteristic of the area of "upward transition", are essentially confined to the commuting hinterland of Edmonton.

## Chapter Five Footnotes

1. A factor matrix containing all variable loadings is presented in Appendix IV (A).

2. Factor scores are *standardized*, that is, they have a mean of 0.0 and a standard deviation of 1.0.

3. Factor scores for the second, third and fourth factors are presented in Appendix III (B).

4. Hierarchical inclusion is used when a causal or sequential ordering of independent variables is evident. In contrast, common stepwise regression techniques select variables according to pre-established criteria. Usually, variables that make the greatest overall contribution to the multiple regression model are entered first (forward inclusion) or are deleted last (backward elimination), followed/preceeded by variables that account for the greatest/least amount of residual explanation, assuming that predetermined criteria are satisfied. Stepwise regression techniques yield an optimal prediction equation containing as few predictor variables as possible, however, when causal ordering is suspected is evident, stepwise regression will produce misleading results, and hierarchical inclusion becomes necessary. Since the correlation coefficient of 0.44 between the two independent variables of distance and size suggests that the former is affecting the latter, distance is entered into the equation first; once its effects on population are removed, population is added into the model to ascertain whether it makes a significant contribution to the overall prediction of the dependent variable. (For a detailed explanation of the differences between hierarchical inclusion and stepwise regression see King (1969)).

5. See Appendix V (B).

6. Incorporating the occupation structure of urban centers as an independent variable in the regression models would serve to explain, in part, observed deviations from the general form of development levels, predicted on the basis of distance, population and commuting. Drayton Valley, for example, was relatively distant from Edmonton and had low levels of commuting, yet exhibited a high level of development characteristic of urban centers in areas of *upward transition*. Conversely, Stony Plain, although close to Edmonton and with a level of commuting in excess of 10%, nonetheless had the lowest level of development among all urban centers in the growth space. These deviations are likely attributable, in part, to the occupation structure and underlying economic base of these centers: the economic base and corresponding occupation structure of Drayton Valley in 1971 derived largely from oil-related activities of resource extraction that featured high wage levels; the role of Stony Plain in 1971 as an agricultural service center implied that its economic base and occupational structure was dependent, to a large degree, on a declining activity.

7. Census of Canada, Occupation Groups by Sex, Series A, Tables 61-80, Items 1-65, Alberta Bureau of Statistics, Enumeration Area Printouts, November, 1974.

8. See Appendix II (B).

9. Census of Canada, Population: Geographic Distributions - Municipalities, Census Metropolitan Areas and Census Agglomerations, Catalogue 92-806, Vol. 1, Part 1, (Bulletin 1.7), June, 1977.

10. This assumes that the extent of the commuting hinterland has not changed significantly between 1971 and 1976.

# CHAPTER SIX

## SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The purpose of this thesis was to identify and investigate those factors that gave rise to or accounted for variation among levels of development of urban centers throughout the growth space of Edmonton. The major objectives of the study were to construct an *index of development*, reflecting the state or level of economic prosperity or development and to ascertain the extent to which hypothesized factors explained variation among levels of development. Principal components analysis was used to construct the *index of development* that was based on a variety of development measures, and a series of linear regression analyses was carried out to test hypotheses relating to the form of development levels of urban centers throughout the growth space.

### I. Findings and Conclusions of the Study

The foregoing linear regression analyses provided preliminary evidence to support the series of linked hypotheses presented in Chapter One. Considering urban centers of the growth space as a whole, it was found that levels of development declined with distance from Edmonton (Hypothesis One), on the one hand, and with decreasing urban center size (Hypothesis Two), on the other hand. Although the inverse relation between development levels and distance and the positive relation between development levels

and size were both significant, the independent variables of distance and size, by themselves, did not account for a large proportion of variation among the dependent development level variable. A multiple linear regression of development levels on first distance and then size was therefore carried out to ascertain the combined effects of the two independent variables on the dependent variable. Both independent variables contributed significantly to the overall relation, that is, the partial regression coefficients significantly raised the coefficient of determination. The strength of the relation indicated that approximately one-half of the variation among levels of development was explained by the combined effects of both distance and size.

Despite the increased explanatory power provided by the multiple linear regression of development levels on distance and size, approximately one-half of the variation among levels of development was left unaccounted. Hypotheses Three and Four, however, clearly suggested that the overall significance of the above described relations derived essentially from those urban centers within the commuting hinterland of Edmonton. When levels of development of the eight urban centers in the commuting hinterland were regressed on distance, a significant inverse relation between development levels and distance was evident. The strength of this relation indicated that distance accounted for almost three quarters of the variation among levels of development of these urban centers, and suggested that, given the small sample size, it was unlikely that other independent variables would have significantly increased the strength of the relation. Similarly,

a regression of development levels on urban size for the same group of eight centers in the commuting hinterland revealed a significant relation between the dependent and independent variables, in which the latter accounted for just over three quarters of the variation in the former. A multiple linear regression of development levels of urban centers in the commuting hinterland on distance and size was not attempted because of the multicollinearity of the two independent variables. In contrast, the independent variables of distance and size, neither individually nor together, explained a significant proportion of the variation among development levels of the fourteen urban centers beyond the immediate commuting hinterland of Edmonton.

A comparison between mean development level of urban centers within and beyond the immediate commuting hinterland showed that the former group of urban centers had a significantly higher mean level of development than the latter. This strongly suggests that the development *profile* of most urban centers in the commuting hinterland is characteristic of areas of *upward transition*, while the majority of outlying urban centers possess attributes of development similar to areas of *downward transition*. The implication of these findings is that Edmonton is exerting an impact on levels of development of urban centers in the commuting hinterland via the labour market (Hypothesis Four). The spatial form of this impact features an area of *upward transition* corresponding roughly to the extent of Edmonton's commuting hinterland, and a surrounding area of *downward transition* (Hypothesis Three).

The overwhelming complexities underlying urban-economic growth and the intricacies of urban spatial interactions underscore the complex nature of development. The findings of the present study strongly suggest that identifiable patterns underlie the spatial form of development. Distance from Edmonton, urban center size, and level of commuting, together or in combination, had varying but significant effects on levels of development of urban centers throughout the growth space of Edmonton. However, in many instances, the overall strength and consistency of these patterns was not great enough to preclude consideration of other factors or variables that might also have significantly affected levels of development. In other words, inclusion of additional variables might have increased the explanatory power of the models used in the present study and subsequently decreased the residual or unexplained variance evident in these models. However, since the research focused on hypotheses relating primarily to geographic location, consideration of additional non-geographic variables, notably occupation structure and economic base, was excluded from the present analysis.

The conclusions that can be drawn from the study findings relate to the degree to which the original hypotheses have been validated:

Hypotheses One and Two: Considering the urban centers of the growth space as a whole, the existence of an inverse relation between development levels and distance from Edmonton was confirmed. Similarly, a positive

relation between development levels and urban center size was also established. Since the strength and significance of these relationships declined beyond a certain distance from Edmonton, this distance being primarily determined by the commuting hinterland, it can be concluded that the extent of the growth space was not a significant factor in these overall relationships.

Hypotheses Three and Four: A pattern underlying the form of development levels in the growth space of Edmonton was discerned. The pattern featured:

(1) high levels of development among urban centers within approximately 35 kilometers of Edmonton, and;

(2) with few exceptions, urban centers beyond 35 kilometers exhibited low levels of development.

This pattern corresponds to the spatial framework of Friedmann's *center-periphery* model, that is, an area of *upward transition* characterized by high levels of development, surrounded by an area of *downward transition* with low levels of development. On the basis of these findings, Hypothesis Three, relating to the form of development levels around Edmonton, may be accepted.

High levels of development characteristic of *upward transitional* areas were essentially confined to urban centers in the commuting hinterland, and in particular, to the five centers closest to Edmonton. While these findings support Hypothesis Four, it should be noted that the area of *upward transition* was not congruent with the commuting hinterland; the latter extended approximately 40 kilometers from Edmonton whereas the former was

confined to a radius of about 35 kilometers around Edmonton. However, these areal differences appeared to have lessened between 1971 and 1976, as evidenced by the rapid population growth of urban centers at the periphery of the commuting hinterland - between 35 to 40 kilometers from Edmonton, and the corresponding increases of development levels associated with this growth. These trends suggest that a convergence of *upward transitional* areas with the commuting hinterland may be taking place, implying that the magnitude of Edmonton's impact via the labour market is consolidating.

## II. Recommendations for Further Study

The conclusions obtained from the foregoing investigation point to a number of areas in which further study appears relevant:

- Since distance was shown to be a critical locational determinant underlying the form of development levels, it might be more realistic to use other distance measurements such as time or cost of origin-destination trips, particularly those that involve commuting.

- Differences between the mean development level of urban centers in the commuting hinterland and those beyond the commuting hinterland indicated that Edmonton's impact via the labour market is a major factor underlying the form of development levels. However, the criterion used to delineate the commuting hinterland - all urban centers with levels of commuting exceeding 10%, was somewhat

arbitrary. Research relating to the impact of commuting on surrounding urban centers is necessary to establish the critical threshold or range of commuting levels beyond which the favourable impacts of commuting are evident. A detailed study of metropolitan commuting patterns would also provide additional information about the magnitude of metropolitan impact on urban spatial interaction.

Although the independent variables of distance and size were treated as distinct variables in the regression models it may prove useful to combine the two into a model that indexes urban spatial interaction. Two approaches are suggested. One approach involves the gravity model which assumes that "interaction between two centers of population varies inversely with some function of the size population of the two centers and inversely with some function of the distance between them"(Carrothers, 1956, p. 94). A second approach entails the use of the potential model, in which interaction between one center of population and all other population centers can be determined. The criteria used to select the *other* centers could be based on a distance measurement. In both models the size of the labour force could be substituted for the population size and a functional measurement of distance could be employed. Particular attention would be directed toward the function of the exponent.

- Since the log transformations of the independent variables improved the results obtained from the regression models, other forms of transformation should be investigated; there may not be a simple relation between development levels and the variables used in the study.

- Since the variables used in the models did not explain the patterns underlying the form of development among urban centers beyond the commuting hinterland, other variables should be examined. These might include such non-locational variables as occupation structure and economic base.

- A similar study using recent data should be undertaken to assess the changing nature of locational determinants that underlie the form of development levels. Since comparable data are available for other metropolitan areas throughout Canada, results of this study could be compared to the findings of similar studies to ascertain whether the results of the present study are indicative of underlying patterns shaping urban growth and development.

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# APPENDIX I

Population and Growth Rates of Urban Centers in Alberta, 1961 - 1971*

| Urban Center | Population (1961) | Population (1971) | % Population Change |
|---|---|---|---|
| Airdrie | 524 | 1089 | 10.8 |
| Beaverlodge | 897 | 1157 | 2.9 |
| Bellevue | 1323 | 1242 | -0.6 |
| Black Diamond | 1043 | 945 | -0.9 |
| Blairmore | 1980 | 2037 | 0.3 |
| Bonnyville | 1736 | 2587 | 4.9 |
| Bow Island | 1122 | 1159 | 0.3 |
| Brooks | 2827 | 3986 | 4.1 |
| Canmore | 1445 | 1538 | 0.1 |
| Cardston | 2801 | 2686 | -0.4 |
| Castor | 1025 | 1166 | 1.4 |
| Claresholm | 2143 | 2935 | 3.7 |
| Coaldale | 2592 | 2798 | 0.8 |
| Cochrane | 857 | 1046 | 2.2 |
| Cold Lake | 1307 | 1309 | 0.1 |
| Coleman | 1713 | 1534 | -1.0 |
| Didsbury | 1254 | 1821 | 4.5 |
| Drumheller | 2931 | 5446 | 8.6 |
| Edson | 3198 | 3818 | 1.9 |
| Fairview | 1506 | 2109 | 4.0 |
| Fort McLeod | 2490 | 2709 | 0.9 |
| Fort McMurray | 1186 | 6847 | 95.4 |

APPENDIX I (con't.)

Population and Growth Rates of Urban Centers in Alberta, 1961 - 1971

| Urban Center | Population (1961) | Population (1971) | % Population Change |
|---|---|---|---|
| Grand Center | 1493 | 2088 | 4.0 |
| Grande Prairie | 8352 | 13079 | 5.7 |
| Grimshaw | 1095 | 1714 | 11.3 |
| Hanna | 2645 | 2545 | -0.4 |
| High River | 2276 | 2676 | 1.8 |
| Hinton | 3529 | 4911 | 3.9 |
| Innisfail | 2270 | 2474 | 0.9 |
| Lac la Biche | 1314 | 1791 | 3.6 |
| Lloydminster | 2944 | 4738 | 6.1 |
| Lethbridge | 35454 | 41217 | 3.2 |
| Magrath | 1338 | 1215 | -0.9 |
| Manning | 896 | 1071 | 3.9 |
| McLennan | 1078 | 1090 | 0.1 |
| Medicine Hat | 24484 | 26518 | 1.7 |
| Nanton | 1054 | 991 | -0.6 |
| Okotoks | 1043 | 1247 | 2.0 |
| Olds | 2433 | 3376 | 3.9 |
| Peace River | 2543 | 5039 | 9.8 |
| Picture Butte | 978 | 1008 | 0.3 |
| Pincher Creek | 2691 | 3227 | 2.0 |
| Provost | 1022 | 1489 | 4.6 |
| Raymond | 2362 | 2156 | -0.9 |
| Redcliffe | 2221 | 2255 | 0.2 |
| Red Deer | 19612 | 27674 | 8.2 |
| Rocky Mountain House | 2360 | 2968 | 2.6 |

APPENDIX I (con't.)

Population and Growth Rates of Urban Centers in Alberta, 1961 - 1971

| Urban Center | Population (1961) | Population (1971) | % Population Change |
|---|---|---|---|
| Spirit River | 890 | 1091 | 4.5 |
| Stettler | 3638 | 4168 | 1.5 |
| St. Paul | 2823 | 4161 | 4.7 |
| Strathmore | 924 | 1148 | 2.4 |
| Swan Hills | 643 | 1376 | 11.4 |
| Sylvan Lake | 1381 | 1597 | 1.6 |
| Taber | 3951 | 4765 | 2.1 |
| Three Hills | 1491 | 1354 | -0.9 |
| Valleyview | 1077 | 1708 | 5.9 |
| Vauxhall | 942 | 1016 | 0.8 |
| Vermillion | 2449 | 2915 | 3.8 |
| Vulcan | 1310 | 1384 | 0.6 |
| Wainwright | 3351 | 3872 | 1.6 |
| Whitecourt | 1654 | 2279 | 9.4 |

* Excludes urban centers listed in Table 3-3

# APPENDIX II (A)

## Original Variables Used to Construct the *Index of Development* - Static Variables

| Urban Center | INC71 | AMDV71 | TENURE71 | AUTO71 | DRYER71 |
|---|---|---|---|---|---|
| Sherwood Park | 6997 | 25297 | 6.02 | 1.49 | 85.5 |
| St. Albert | 6686 | 25068 | 6.61 | 1.50 | 89.7 |
| Spruce Grove | 6342 | 22577 | 6.41 | 1.44 | 64.2 |
| Leduc | 5774 | 18539 | 2.38 | 1.19 | 58.1 |
| Fort Saskatchewan | 6171 | 20929 | 1.75 | 1.18 | 45.6 |
| Morinville | 4735 | 11892 | 3.00 | 1.09 | 47.4 |
| Stony Plain | 4274 | 16254 | 3.24 | 1.10 | 47.1 |
| Devon | 5714 | 15139 | 3.37 | 1.39 | 63.4 |
| Redwater | 5552 | 11120 | 2.57 | 1.01 | 48.0 |
| Wetaskiwin | 4694 | 14162 | 1.91 | 1.08 | 47.4 |
| Tofield | 4133 | 8511 | 3.13 | 0.98 | 51.5 |
| Westlock | 4757 | 15212 | 2.03 | 0.79 | 44.8 |
| Camrose | 4560 | 15314 | 2.08 | 1.17 | 53.6 |
| Vegreville | 4232 | 12674 | 2.74 | 0.92 | 41.9 |
| Ponoka | 4597 | 13645 | 2.20 | 1.11 | 49.8 |
| Barrhead | 4164 | 12061 | 2.12 | 0.92 | 44.0 |
| Lacombe | 4851 | 13386 | 2.42 | 1.07 | 55.0 |
| Mayerthorpe | 5345 | 10844 | 2.28 | 1.10 | 39.7 |
| Viking | 4848 | 11167 | 2.62 | 0.97 | 53.2 |
| Rimbey | 4044 | 9665 | 2.42 | 0.99 | 48.3 |
| Drayton Valley | 6204 | 15556 | 1.86 | 1.21 | 65.1 |
| Athabasca | 4428 | 12939 | 1.73 | 0.99 | 37.5 |
| Edmonton | 5777 | 23572 | 1.23 | 1.12 | 52.2 |

APPENDIX II (A) (con't.)

Original Variables Used to Construct the *Index of Development* - Static Variables

| Urban Center | LFPR71 | LT15YR71 | PCCIRC71 | PCPO71 |
|---|---|---|---|---|
| Sherwood Park | 66.2 | 43.4 | 23.2 | 5.2 |
| St. Albert | 60.8 | 41.7 | 21.6 | 7.7 |
| Spruce Grove | 59.3 | 42.0 | 20.6 | 10.5 |
| Leduc | 53.7 | 33.3 | 18.5 | 17.5 |
| Fort Saskatchewan | 51.5 | 46.4 | 22.5 | 17.4 |
| Morinville | 50.3 | 41.2 | 17.3 | 13.0 |
| Stony Plain | 46.5 | 24.0 | 21.6 | 30.5 |
| Devon | 48.0 | 21.8 | 23.5 | 11.9 |
| Redwater | 52.3 | 31.5 | 16.5 | 15.7 |
| Wetaskiwin | 50.8 | 28.1 | 14.9 | 21.5 |
| Tofield | 48.6 | 25.4 | 20.8 | 24.0 |
| Westlock | 51.7 | 29.2 | 16.3 | 25.6 |
| Camrose | 50.8 | 26.9 | 14.4 | 19.0 |
| Vegreville | 47.9 | 25.6 | 17.2 | 20.2 |
| Ponoka | 56.6 | 28.3 | 16.3 | 20.5 |
| Barrhead | 47.1 | 36.2 | 16.6 | 23.7 |
| Lacombe | 50.9 | 26.3 | 11.3 | 27.9 |
| Mayerthorpe | 53.7 | 29.0 | 16.7 | 24.3 |
| Viking | 54.7 | 23.8 | 20.6 | 22.4 |
| Rimbey | 48.6 | 30.4 | 19.5 | 26.1 |
| Drayton Valley | 59.3 | 38.5 | 17.6 | 18.8 |
| Athabasca | 56.2 | 30.0 | 17.4 | 28.2 |
| Edmonton | 65.2 | 34.5 | 28.7 | 26.9 |

## APPENDIX II (B)

### Original Variables Used to Construct the *Index of Development* - Dynamic Variables

| Urban Center | INC6171 | AMDV6171 | AUTO6171 | LFPR6171 | PCPO6171 |
|---|---|---|---|---|---|
| Sherwood Park | 221 | 3058 | 31.9 | 11.6 | 16.5 |
| St. Albert | 1890 | 4969 | 45.6 | 9.5 | 7.3 |
| Spruce Grove | 1770 | 4058 | 46.9 | 16.2 | -14.2 |
| Leduc | 1606 | 3243 | 40.0 | 5.1 | -20.9 |
| Fort Saskatchewan | 651 | 2438 | 45.7 | 5.1 | -13.4 |
| Morinville | 1231 | 1114 | 45.3 | -4.9 | -15.7 |
| Stony Plain | 271 | 3141 | 35.8 | -0.8 | 18.6 |
| Devon | 409 | 5173 | 36.3 | -20.0 | -4.8 |
| Redwater | 453 | 588 | 16.1 | -6.1 | 36.0 |
| Wetaskiwin | 598 | -247 | 25.6 | -1.2 | 24.3 |
| Tofield | 962 | 1519 | 36.1 | -7.1 | -12.7 |
| Westlock | 1066 | 3731 | 29.5 | -1.0 | 0.6 |
| Camrose | 932 | 1423 | 44.4 | 3.3 | 32.9 |
| Vegreville | 735 | 1256 | 70.3 | -1.8 | 1.7 |
| Ponoka | 338 | 221 | 44.2 | -2.9 | 11.4 |
| Barrhead | 311 | 671 | 19.5 | -10.3 | 34.6 |
| Lacombe | 883 | 873 | 30.5 | 6.3 | 38.8 |
| Viking | 1638 | 1668 | 41.0 | 4.3 | -7.9 |
| Mayerthorpe | 1093 | 998 | 44.8 | 12.3 | 8.8 |
| Rimbey | -145 | -815 | 23.8 | -13.2 | 41.8 |
| Drayton Valley | 903 | 3684 | 39.1 | -7.5 | 25.3 |
| Athabasca | 1013 | 3821 | 28.6 | 3.5 | 38.5 |
| Edmonton | 1196 | 402 | 11.4 | 1.2 | 82.2 |

APPENDIX II (B) (con't.)

Original Variables Used to Construct the *Index of Development* - Dynamic Variables

| Urban Center | POP6171 | DWELLNEW |
|---|---|---|
| Sherwood Park | 38.9 | 80.3 |
| St. Albert | 19.1 | 68.1 |
| Spruce Grove | 55.4 | 83.9 |
| Leduc | 7.0 | 46.9 |
| Fort Saskatchewan | 9.3 | 50.0 |
| Morinville | 5.8 | 39.7 |
| Stony Plain | 3.5 | 30.0 |
| Devon | 0.4 | 20.5 |
| Redwater | 1.3 | 21.9 |
| Wetaskiwin | 1.8 | 26.8 |
| Tofield | 0.2 | 16.4 |
| Westlock | 7.7 | 48.2 |
| Camrose | 2.5 | 28.1 |
| Vegreville | 2.7 | 28.9 |
| Ponoka | 1.2 | 21.4 |
| Barrhead | 2.3 | 27.8 |
| Lacombe | 1.3 | 21.9 |
| Viking | 5.6 | 39.0 |
| Mayerthorpe | 1.3 | 15.0 |
| Rimbey | 1.1 | 19.8 |
| Drayton Valley | 0.3 | 12.6 |
| Athabasca | 1.9 | 20.2 |
| Edmonton | 3.6 | 40.5 |

## APPENDIX II (C)

### Independent Variables

| Urban Center | LOGKLMS | LOGPOP71 | COMM71 |
|---|---|---|---|
| Sherwood Park | 1.158 | 4.158 | 57.1 |
| St. Albert | 1.204 | 4.072 | 59.3 |
| Spruce Grove | 1.459 | 3.483 | 59.1 |
| Leduc | 1.505 | 3.602 | 25.8 |
| Fort Saskatchewan | 1.526 | 3.758 | 11.7 |
| Morinville | 1.536 | 3.169 | 23.0 |
| Stony Plain | 1.547 | 3.248 | 11.2 |
| Devon | 1.584 | 3.167 | 22.7 |
| Redwater | 1.772 | 3.110 | 6.5 |
| Wetaskiwin | 1.848 | 3.797 | 3.9 |
| Tofield | 1.857 | 2.966 | 8.5 |
| Westlock | 1.928 | 3.511 | 3.4 |
| Camrose | 1.975 | 3.938 | 0.8 |
| Redwater | 2.003 | 3.567 | 3.0 |
| Ponoka | 2.010 | 3.645 | 0.6 |
| Barrhead | 2.079 | 3.448 | 1.5 |
| Lacombe | 2.085 | 3.536 | 0.8 |
| Viking | 2.139 | 3.015 | 0.0 |
| Mayerthorpe | 2.144 | 3.071 | 1.9 |
| Rimbey | 2.149 | 3.161 | 0.0 |
| Drayton Valley | 2.154 | 3.591 | 2.1 |
| Athabasca | 2.158 | 3.247 | 0.0 |

## APPENDIX III (A)

### Data Collection Units - Enumeration Areas (1961)*

| | Enumeration Area | Enumeration District | Census Division |
|---|---|---|---|
| Sherwood Park | 204, 214 | 808 | 11 |
| St. Albert | 222, 227, 234-35, 247 | 809 | 11 |
| Spruce Grove | 177 | 810 | 11 |
| Leduc | 130-31, 145 | 817 | 11 |
| Fort Saskatchewan | 200-02, 208 | 808 | 11 |
| Morinville | 166 | 810 | 11 |
| Stony Plain | 167 | 810 | 11 |
| Devon | 129 | 817 | 11 |
| Redwater | 144 | 816 | 13 |
| Wetaskiwin | 122-27 | 817 | 11 |
| Tofield | 123 | 816 | 10 |
| Westlock | 144, 156 | 802 | 13 |
| Camrose | 135-39, 156-57 | 803 | 10 |
| Vegreville | 125-26, 148 | 816 | 10 |
| Ponoka | 114-16 | 817 | 08 |
| Barrhead | 179-81 | 810 | 13 |
| Lacombe | 111-13 | 817 | 08 |
| Mayerthorpe | 185 | 810 | 13 |
| Viking | 144 | 803 | 10 |
| Rimbey | 117 | 817 | 08 |
| Drayton Valley | 163-64, 205-6 | 810 | 11 |
| Athabasca | 143, 160 | 802 | 13 |

* Not areally compared to 1971 Enumeration Areas

## APPENDIX III (B)

### Data Collection Units - Enumeration Areas (1971)*

| | Enumeration Areas | Enumeration District | Census Division |
|---|---|---|---|
| Sherwood Park | 12-28, 31 | 815 | 11 |
| St. Albert | 359-73 | 810 | 11 |
| Spruce Grove | 268-71 | 819 | 11 |
| Leduc | 316-22 | 819 | 11 |
| Fort Saskatchewan | 151-58 | 815 | 11 |
| Morinville | 168-69 | 815 | 11 |
| Stony Plain | 370-71 | 819 | 11 |
| Devon | 262-63 | 819 | 11 |
| Redwater | 265-66 | 815 | 13 |
| Wetaskiwin | 59-68 | 819 | 11 |
| Tofield | 256-57 | 818 | 10 |
| Westlock | 412-16 | 815 | 13 |
| Camrose | 456-72 | 802 | 10 |
| Vegreville | 209-15 | 818 | 10 |
| Ponoka | 10-18 | 819 | 08 |
| Barrhead | 463-67 | 815 | 13 |
| Lacombe | 312-16 | 816 | 08 |
| Mayerthorpe | 507-08 | 815 | 13 |
| Viking | 318-19 | 802 | 10 |
| Rimbey | 113-15 | 819 | 08 |
| Drayton Valley | 205-09 | 817 | 11 |
| Athabasca | 355-67 | 815 | 13 |

* Not areally comparable to 1961 Enumeration Areas

## APPENDIX IV (A)

### Variable Loadings on First Four Factors

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|---|
| INC71 | (88)* | -25 | -12 | 22 |
| AMDV71 | (91)* | -08 | -03 | -01 |
| TENURE71 | (86)* | -01 | 15 | -25 |
| AUTO71 | (86)* | -26 | 10 | 09 |
| DRYER71 | (81)* | -32 | 4 | 07 |
| LFPR71 | (78)* | -02 | -34 | 17 |
| LT15YR71 | (67)* | -17 | (-42) | -01 |
| PCCIRC71 | (53) | -32 | (58)* | -21 |
| PCPO71 | (-81)* | 26 | -02 | -04 |
| INC6171 | (45) | (58)* | -04 | (53) |
| AMDV6171 | (62)* | -08 | (44) | 35 |
| AUTO6171 | 29 | (53)* | (43) | 08 |
| LFPR6171 | (61)* | (53) | -32 | 00 |
| PCPO6171 | (-42) | (-69)* | -23 | (40) |
| POP6171 | (86)* | 18 | -10 | 36 |
| DWELLNEW | (88)* | 18 | -11 | -26 |

Decimal points ommitted

Correlations greater than 40 are shown in brackets

Highest variable Loading indicated by asterisk (*)

## APPENDIX IV (B)

### Factor Scores for the Second, Third and Fourth Factors

| | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|
| Sherwood Park | 0.96 | 1.47 | -1.55 |
| St. Albert | 1.12 | -0.45 | 1.28 |
| Spruce Grove | 0.34 | 2.61 | 0.67 |
| Leduc | -0.15 | -0.52 | 1.16 |
| Fort Saskatchewan | 0.19 | -0.26 | -0.11 |
| Morinville | -0.36 | 0.32 | 0.24 |
| Stony Plain | 1.21 | 0.99 | -0.46 |
| Devon | 3.11 | -1.37 | -0.12 |
| Redwater | -0.73 | -0.97 | -1.37 |
| Wetaskiwin | -1.09 | -0.18 | -0.83 |
| Tofield | 0.55 | -0.33 | -0.06 |
| Westlock | -0.26 | 0.62 | 0.17 |
| Camrose | -0.55 | 0.20 | 0.63 |
| Vegreville | 0.27 | 0.48 | 1.15 |
| Ponoka | -0.51 | -0.22 | -0.28 |
| Barrhead | -0.68 | -0.12 | -1.65 |
| Lacombe | -1.63 | -0.27 | 0.16 |
| Mayerthorpe | -0.93 | 0.32 | 1.19 |
| Viking | -0.17 | 0.86 | 0.82 |
| Rimbey | 0.05 | -0.08 | -2.23 |
| Drayton Valley | 0.05 | -2.24 | 0.63 |
| Athabasca | -0.80 | -0.87 | 0.55 |

## APPENDIX V (A)

### $X^2$ Test of Normality for DEVLEVEL

| Classes* (N) | Observed (O) Frequency Distribution | Expected (E) Frequency Distribution | O-E | $(O-E)^2$ | $(O-E)^2/N$ |
|---|---|---|---|---|---|
| -2sd to -1sd | 3 | 3.5 | -0.5 | 0.25 | 0.07 |
| -1sd to $\bar{x}$ | 10 | 7.5 | 2.5 | 6.25 | 0.83 |
| $\bar{x}$ to +1sd | 5 | 7.5 | -2.5 | 6.25 | 0.83 |
| +1sd to +2sd | 4 | 3.5 | 0.5 | 0.25 | 0.07 |
| Total | 22 | 22.0 | - | - | 1.80 |

*DEVLEVEL: mean (x) = 0.00
standard deviation (sd) = 1.00

$x^2 = 1.80$

df = N-3 = 1

significance level = 0.01

$x^2$ table value = 6.635

APPENDIX V (A) (con't.)

$X^2$ Test for Normality for LOGKLMS

| Classes* (N) | Observed (O) Frequency Distribution | Expected (E) Frequency Distribution | O-E | $(O-E)^2$ | $(O-E)^2/N$ |
|---|---|---|---|---|---|
| -2sd to -1sd | 3 | 3.5 | -0.5 | 0.25 | 0.07 |
| -1sd to $\bar{x}$ | 6 | 7.5 | -1.5 | 2.25 | 0.31 |
| $\bar{x}$ to +1sd | 8 | 7.5 | 0.5 | 0.25 | 0.03 |
| +1sd to +2sd | 5 | 3.5 | 1.5 | 2.25 | 0.64 |
| Total | 22 | 22.0 | - | - | 1.05 |

*LOGKLMS: mean ($\bar{x}$) = 1.8108
standard deviation (sd) = 0.3192

$x^2 = 1.05$

df = N-3 = 1

significance level = 0.01

$x^2$ table value = 6.635

APPENDIX V (A) (con't.)

$x^2$ Test for Normality for LOGPOP71

| Classes* (N) | Observed (O) Frequency Distribution | Expected (E) Frequency Distribution | O-E | $(O-E)^2$ | $(O-E)^2/N$ |
|---|---|---|---|---|---|
| -2sd to -1sd | 4 | 3.5 | 0.5 | 0.25 | 0.07 |
| -1sd to $\bar{x}$ | 6 | 7.5 | -1.5 | 2.25 | 0.31 |
| $\bar{x}$ to +1sd | 9 | 7.5 | 1.5 | 2.25 | 0.31 |
| +1sd to +2sd | 3 | 3.5 | -0.5 | 0.25 | 0.07 |
| Total | 22 | 22.0 | - | - | 0.76 |

*LOGPOP71: mean ($\bar{x}$) = 3.4644
standard deviation (sd) = 0.3416

$x^2 = 0.76$

df = N-3 = 1

significance level = 0.01

$x^2$ table value = 6.635

## APPENDIX V (B)

### Differences Between Sample Means

$$"t" = \frac{(X_1) - (X_2)}{(S_1^2/N_1) + (S_2^2/N_2)}$$

$$"t" = \frac{(0.53) - (-0.30)}{(1.30^2/8) + (0.66)^2/14}$$

$$"t" = 1.69$$

$$df = (N-2) = 20$$

significance level = 0.90